2023 IFEES/GEDC/EPOKA

INTERNATIONAL CONFERENCE
CHALLENGES IN THE WESTERN BALKANS:
INFRASTRUCTURE AND DEVELOPMENT IN THE REGION

BOOK OF PROCEEDINGS

TIRANA 2023

EPOKA University

Global Engineering Deans Council

International Federation of Engineering Education Societies

Magna Charta Observatory

Ss. Cyril and Methodius University in Skopje

Akademia e Shkencave e Shqipërisë

Challenges in the Western Balkans:

Infrastructure and Development in the Region

International Conference 2023

BOOK OF PROCEEDINGS

ISBN: 978-9928-135-40-7

Challenges in the Western Balkans: Infrastructure and Development in the Region

International Conference 2023

Book of Proceedings

Editors

Prof. Dr. Hüseyin Bilgin

Mr. Bredli Plaku

Publisher

EPOKA UNIVERSITY

All rights reserved

Book of Proceedings

Challenges in the Western Balkans: Infrastructure and Development in the Region International Conference 2023

2023 IFEES/GEDC/EPOKA

29-30 March 2023

Tirana, Albania

Organizers

EPOKA University	Tirana, Albania
Global Engineering Deans Council	Virginia, United States
International Federation of Engineering Education Societies	Virginia, United States
Observatory Magna Charta Universitatum	Bologna, Italy
Ss. Cyril and Methodius University in Skopje	Skopje, North Macedonia
Academy of Sciences of Albania	Tirana, Albania

Committees

Local Organizing Committee

Prof. Dr. Ahmet Öztaş — Chair
Rector of EPOKA University

Assoc. Prof. Dr David Felsen — Co-Chair
Vice-Rector for International Relations at EPOKA University

Prof. Dr. Hüseyin Bilgin — Co-Chair
Faculty of Architecture and Engineering at EPOKA University

Prof. Dr. Abdurrahman Işık — Member
Faculty of Economics and Administrative Sciences at EPOKA University

Assoc. Prof. Dr. Miriam Ndini — Member
Faculty of Architecture and Engineering at EPOKA University

Dr. Alba Gërdeci — Member
Head of Rector's Cabinet and International Relations Office at EPOKA University

Dr. Mirela Alhasani (Dubali) — Member
Faculty of Law and Social Sciences at EPOKA University

Ms. Elvira Meti — Member
Faculty of Economics and Administrative Sciences at EPOKA University

Mr. Altin Bora — Member
Head of Office of the Administrator at EPOKA University

Ms. Endi Tirana — Member
Specialist at International Relations Office at EPOKA University

International Advisory Committee

Dr. Hans Jürgen Hoyer
Secretary General of the International Federation of Engineering Education Societies (IFEES)
Executive Secretary of the Global Engineering Deans Council (GEDC)

Mr. David Lock
Secretary General of Magna Charta Observatory (MCO)

Dr. Stephanie Farrell
President of International Federation of Engineering Education Societies (IFEES)
Founding chair of the Department of Experimental Engineering Education (ExEEd)

Prof. Dr. Nikola Jankulovski

Rector of Ss. Cyril and Methodius University in Skopje (UKIM)

Prof. Sunil Maharaj

Global Engineering Deans Council (GEDC) Chair Elect
Dean of the Faculty of Engineering, Built Environment and IT University of Pretoria, South Africa

Dr. Sushma Kulkarni

Director of Rajarambapu Institute of Technology, India
Top 100 Most Influential Directors of India (Education) by World Education Congress 2016

Ms. Aliki Pappas

International Communications Manager of IFEES/GEDC

Keynote Speakers

Dr. Michael K. J. Milligan — United States

Executive Director and Chief Executive Officer of ABET

Mr. Paul Gilbert — Canada

CEO of Quanser

Prof. Michael Murphy — Ireland

President of European University Association (EUA)

Dr. Stephanie Farrell — United States

President of International Federation of Engineering Education Societies (IFEES)
Founding chair of the Department of Experimental Engineering Education (ExEEd)

Prof. Sunil Maharaj — South Africa

Global Engineering Deans Council (GEDC) Chair Elect
Dean of the Faculty of Engineering, Built Environment and IT University of Pretoria, South Africa

Mr. David Lock — United Kingdom

Secretary General of Magna Charta Observatory (MCO)

Dr. Hans Jürgen Hoyer — United States

Executive Secretary of the Global Engineering Deans Council (GEDC)
Secretary General of the International Federation of Engineering Education Societies (IFEES)

Dr. Jaime Bonilla Rios — Mexico

Dean of Tecnológico de Monterrey

Ms. Ardiana Sokoli — Albania

Vice President of Real Estate & Hospitality and Board Member at Balfin Group

Ms. Ledia Telhai — Albania

Chief Executive Director of Real Estate & Hospitality at Balfin Group

Technical Scientific Committee

Abdurrahman Isik	EPOKA University	Albania
Ahmet Öztas	EPOKA University	Albania
Alba Gërdeci	EPOKA University	Albania
Alba Kruja	EPOKA University	Albania
Annabella Barreiro	Institute of Human Language Technology	Portugal
Arban Uka	EPOKA University	Albania
Artan Hysa	Technische Universität München	Germany
Craig Neville	University of CORK	Ireland
David Felsen	EPOKA University	Albania
Dimitar Vesselinov	University of Sofia "St.Kliment Ohridski"	Bulgaria
Dorin Radu	Transilvania University of Brasov	Romania
Edmond Manahasa	EPOKA University	Albania
Eglantina Hysa	EPOKA University	Albania
Ehsan Harirchian	Bauhaus-Universität Weimar	Germany
Elena Lloret	Alicante University	Spain
Grigor Angjeliu	Politecnico Di Milano	Italy
Gylych Jelilov	Philomath University	Nigeria
Hüseyin Bilgin	EPOKA University	Albania
Lubica Vareckova	University "St. Cyril and Methodius	Slovakia
Mahnoosh Biglari	Razi University	Iran
Maria Bakti	University of Szeged	Hungary
Marijana Hadzima-Nyarko	University J.J.Strossmayer in Osijek	Croatia
Mirela Alhasani (Dubali)	EPOKA University	Albania
Miriam Ndini	EPOKA University	Albania
Nadežda Stojkovic	University of Niš, Serbia	United Kingdom
Naida Ademovic	University of Sarajevo	Bosnia Herzegovina
Naser Kabashi	University of Pristina	Kosovo
Neritan Shkodrani	Polytechnic University of Tirana	Albania
Nurettin Can	Vistula University	Poland
Osman Nuri Aras	ISHIK University	Iraq
Paul Igwe	Lincoln University	United Kingdom
Rafael Shehu	Politecnico Di Milano	Italy
Russana Beyleri	University of Sofia St. Kliment Ohridski	Bulgaria
Sokol Dervishi	EPOKA University	Albania
Todor Shopov	University of Sofia "St.Kliment Ohridski"	Bulgaria

Foreword

EPOKA University of Albania hosted the IFEES/GEDC Conference on "Challenges in the Western Balkans: Infrastructure and Development in the Region" on the 28th-29th of March 2023. This milestone scientific event was partnered with two distinguished global engineering organizations: *the Global Engineering Deans Council* (GEDC) and *the International Federation of Engineering Education Societies* (IFEES). This innovative international conference gathered academics, industry leaders, researchers, students, governmental bodies, and non-governmental organizations to address the multidimensional challenges triggered by the post-pandemic Covid-19 global economic recession affecting worldwide and regional Western Balkan development with case-to-case country patterns of development idiosyncrasies.

The European Union regional development reports ascertain that the Western Balkan's average economic growth during the last decade has been substantially lower than the pre-2009 period (European Parliament , 2022). Undoubtfully, the Covid-19 years accelerated the detrimental impact on the existing sluggish economies of the Western Balkans. By 2020, GDP per capita (in Purchasing Power Standards – PPS) ranged from an index of 30 in Albania to 45 in Montenegro against the EU27 average.

Considering such domestic and regional contextual developments and, in relevance with the post-pandemic global predicaments, participants at the IFEES/GEDC Conference aimed to give plausible and feasible answers to the following dilemmas:

- How can countries satisfy infrastructural needs in times of economic challenges in the Western Balkans and beyond?
- How can we continue promoting economic and social development in the Western Balkans region in 2023?
- How can we bring about greater innovation in the Western Balkans and beyond during this era?

This volume is a collection of selected papers delivered at the IFEES/GEDC Conference held onsite at EPOKA University, encompassing four main thematic groups featuring: *Emerging Discourses: Architecture and Urban Planning in Western* Balkans (Resilient Architecture and Urban Planning, Sustainability in Architecture and Urban Design, Building Physics, and Technology, Innovative Methods in Architectural Design, Architectural & Urban Planning Theory, History and Preservation, Computer Applications in Architecture, Landscape Planning and Design, Built Environment, and Human interactions); *Civil Engineering Perspective to Improve Infrastructure in Western Balkans* (Building Materials, Construction Management, Geotechnics, Hydraulics, Structures, Transportation, Civil Engineering Education, Risk assessment and environmental management, Water and Wastewater Treatment, Energy Efficiency and Renewable Energy); *Computer Engineering Innovations* (Information and Communication Technologies, Data Science and Geographic Information Systems, Computer Science and Artificial Intelligence, Digitalization in the Medical field, Internet of things, smart cities, and Cybersecurity challenges in the digital world); *Sustainable Development Perspective to Improve Infrastructure in Western Balkans* (Circular Economy Business Modelling, Alternative Energy Resources, Digitalization, Enterprise Resource Planning Systems).
Characterized by their interdisciplinary nature, the studies in this collection have been conducted utilizing both quantitative and qualitative analysis with overarching research strategies and data collection tools

including experiments, case studies, ethnography, grounded theory, action research, and phenomenology. They vary from Balkan country-level examples such as Albania, and Serbia, to European members such as Hungary, the Czech Republic, Germany, and the global level to the USA, and Africa. These cross-disciplinary inquiries are typified by both deductive and inductive analysis with the goal to shed light on the most sensitive research puzzles in their respective domain of study.

To succinctly illustrate, the papers under Group 1- *Emerging Discourses: Architecture and Urban Planning in Western* Balkans, offer a mosaic of research analyses varying from comparative analyses of housing typologies in socialist regime households with the increasing demands and standards of living to an open free market economy, to automated computational design processes for detached house layout optimization by using python computational algorithms, to the integration of human dimension in large scale infrastructure, to most current thriving debates about the necessity to consolidate renewable energy education as a distinct field within arc architecture, a niche missing in the traditional architectural education.

Similarly, the papers under Group 2- *Civil Engineering Perspective to Improve Infrastructure in Western Balkans*, make a significant contribution to the enlightenment on the most sensitive engineering challenges and advancements by conducting valuable comparative evaluations *of post-earthquake RVS forms for* determining building vulnerability and improving existing method, exploring, and experimenting upon inundation modelling using Hec-Ras Software Farka Stream Case Study; analysing the usage of building information models (BIM) and Point Cloud for Post-Earthquake Damage Assessment: A case study from Albania; and other parametric studies of the effects of seismic pounding between residential structures or the innovate research study on the need to develop low-cost single-axis shaking table based on Arduino microcontroller.

Most strikingly, the collection of papers under the Group 3- *Sustainable Development Perspective to Improve Infrastructure in Western Balkans,* are focused on the social, and gender dimension obstacles that undermine country-level and Western Balkan developments up to quality standards and integration into the EU. These papers bring insights into indicators of life expectancy through Panel Data analysis in the EU countries observing the phenomenon over the period 2001-2021 years; tracing causes that trigger gender gaps by relating to economic barriers; and revealing very original findings on the 'glass ceiling' impact to women's careers salient topics with a sheer vacuum in scientific research and policy recommendation as indicated by the EU reports to reforming democracies of the Western balances where gender equality remains yet a black hole as compared to international standards.

The editors and the contributing authors of this volume hope that these original research findings and overall lessons will turn useful to practitioners of both higher education and industry to obtain some modest, yet evidence-supported answers to regional and global development challenges and barriers. This conference proceeding paves the way for future units of investigation and inquiries as mankind keeps being confronted with unknown threats and challenges that demand rapid scientific reaction.

Prof. Dr. Ahmet Öztaş

Conference Chair

Contents

Committees v

Foreword viii

An Observation of Socialist Period Upper-Class Multifamily Housing in a Tirana Central Zone 1
Edmond Manahasa, Berenis Karamuça

Design Method Automation for Detached House Layout Optimization 12
Anisa Cenaj, Anna Yunitsyna

Integrating Human Scale Developments in Large Scale Infrastructure: "New railway Durres-Tirana-TIA" 20
Arona Muja, Fabio Naselli

Reflections on the Environmental Control Studio: Sustainability in architectural education, encompassing both the building and urban scale 28
Nerina Baçi, Ina Dervishi, Sokol Dervishi

Universality of Housing Design: The Case of Prague, Czech Republic 37
Ernest Shtepani, Anna Yunitsyna

A comparative evaluation of post-earthquake RVS forms for determining building vulnerability and improving existing methods 45
Nurullah Bektaş, Janos Gergely, Orsolya Kegyes-Brassai

Automation Procedures in Surveying Technologies for Accurate and Efficient Surface and Volume Computations 53
Marsed Leti, Paola Berdufi, Mikaela Çela

Development of Low-Cost Single-Axis Shaking Table Based on Arduino Microcontroller 61
Marsed Leti, Dajana Colaj, Agjelos Gjana

Inundation Modelling Using Hec-Ras Software Farka Stream Case Study 68
Mirjeta Blloshmi, Miriam Ndini

Parametric Study of the Effects of Seismic Pounding between Residential Structures 77
Margarita Dajko, Hüseyin Bilgin

Preparing the 21st Century Professionals for the Execution of Major Infrastructure Projects in Western Balkans 85
Željko Torbica, Zoran Cekić

Usage of Building Information Modeling (BIM) and Point Cloud for Post-Earthquake Damage Assessment: A Case Study from Albania 92
Izet Mehmetaj, Armela Kalliri, Miriam Ndini

Indicators of life expectancy – A Panel Data Analysis in EU countries 97
Melisa Huqi, Klaus Isku

Ethics in AI, XR and Digitalization: A Systematic Literature Review 109
Osman Koroglu

The Intersection of Gender and the Economy: Understanding Gender Gaps and How to Address Them; The Case of Albania 116
Arjela Dervishaj, Mirela Alhasani (Dubali)

Relationship between HDI, ICT and Economic Growth: Case of Albania 125
Vangjel Toto, Mirela Alhasani (Dubali)

The Glass Ceiling impacts Women's Careers. The Case of Albania 133
Klea Pashtranjaku, Mirela Alhasani (Dubali)

An Observation of Socialist Period Upper-Class Multifamily Housing in a Tirana Central Zone

Edmond Manahasa[1]*, Berenis Karamuça[1]

[1]*Department of Architecture, Faculty of Architecture and Engineering, EPOKA University, Autostrada Tiranë-Rinas, km. 12, 1032, Tirana, Albania*
** Corresponding author: emanahasa@epoka.edu.al;*

Abstract

This research focuses on the socialist period upper-class housing in the central area of Tirana. The departure point of this study is the continuous urban transformation to which the central areas of Tirana are subject in the post-socialist period, including the multifamily housing in the perimeter of the city center. The study aims to document and reveal the architectural values of multifamily housing planned for the upper class of the socialist regime.
To achieve this goal, there are selected five multifamily housing blocks that were once dwelled for the upper class of the socialist period society and constructed between the years 1962 and 1990. The methodology includes observation, archival research, redrawing, and 3D visualization of these apartment blocks.
The housing blocks included in this research are *"Nëntë Kateshet"* apartment blocks, an apartment block designed by Ibrahim Prushi *("Kafe Flora"),* an apartment block designed by Maks Velo *("Pallati me Kuba"), a* residential complex designed by Faik Alimehmeti and residential complex designed by Petraq Kolevica. The study reveals the architectural values of these housing by analyzing the volumetric composition and their indoor and outdoor spatial features. Finally, the selected multifamily housing blocks are compared to emphasize the similarities in their architectural solutions and values.

Keywords: Socialist Period, Tirana, Upper-Class, Multifamily Housing

1. INTRODUCTION

During the socialist period, Tirana city center was utilized as a public space to manifest socialist propaganda and the Albanian national identity. However, Albania's political relations with the Soviet Union and China also influenced the development city center, as Palace of Culture building (built at the expense of the Old Bazaar) cornerstone was laid from Khrushchev and Tirana Hotel was constructed with Chinese assistance (Bleta, 2010). National Historical Museum accomplished the ensemble of buildings of the city center. They define Skanderbeg square, which is the central public space of Tirana.

Apart from these monumental buildings, in the perimeter of the city center, there were also constructed residential blocks. These residential blocks were planned to accommodate the elite of the socialist regime (Manahasa et al., 2004). This study aims to reveal the architectural features of these multifamily housing blocks located in this central zone of Tirana. In the following sections, there are provided housing development strategies in the socialist period Tirana and are explained architectural features of the selected housing blocks.

2. HOUSING FOR UPPER-CLASS IN TIRANA

In Tirana's case, housing for the upper class varies in different political periods. The first examples are encountered during the establishment period as the capital city under King Zog. During that period, there were designated housing plots for governmental officers, which were implemented in the form of urban villas at the Tirana e Re zone (Manahasa, 2017). This zone was conceptualized as a "garden city" by the Austrian planner Köhler (Aliaj et al., 2004). Apart from this, other urban villas were built into the existing Ottoman period town and belonged to a particular social class in Tirana: the middle/small bourgeoisie, who started to settle in Tirana in the period. Most villas reflected western architecture and a desire for cultural transformation (Dhamo, Thomaj, & Aliaj, 2016). During the Fascist invasion period in 1939, the first multifamily housing blocks were designed for the Italian army administration. These housing blocks reflected the period's highest standards and were featured by Italian influence. These apartments were known locally as *"e Aviacionit"* apartment blocks, apartment blocks of the military corps of engineers, *"Xhenio,"* "*Moskate"* apartment blocks, and *"Te Bardha"* apartment blocks (Bushati, 2012).

After World War II, there was an emergent need for housing due to its devastating consequences and because people started to move from rural to urban areas. Although the government strictly controlled the in-migration to the cities since Tirana became the most important one, its population grew (Islami, Veizaj, & Verdiani, 2018). During the socialist period, dwelling needs were planned based on equality and collectivism principles (Manahasa & Ozsoy, 2020). The planning decisions were taken in the Labour Party congresses and, in many cases, foresaw the construction cost reduction (Bego, 2009). As such multifamily housing realized was featured by reduction of the apartment sizes. Also, prefabrication was seen as a strategy regarding time and quantity affordability. Apart from that, there were used Soviet housing models, and in some cases, voluntary works were used to fulfill the housing needs. (Aliaj, 2003) Although the housing design process was strictly controlled, the most prominent architects, such as Maks Velo and Petraq Kolevica, dared to break restrictions and used designs that would interrupt the homogeneity (Misja & Misja, 2004). Apart from the case studies that are explained in this research, multifamily housing that was designed for the upper class of the socialist period were *"Agimi"* and *"Shallvaret"* (designed by Russian architect Aristov) or *"Miqësia"* designed by Valentina Pistoli (Bushati, 2012).

3. SOCIALIST PERIOD UPPER-CLASS HOUSING IN TIRANA CITY CENTER AND SELECTED CASE STUDIES

Although housing was implemented based on the socialist principles of collectivism and equality, certain dwellings that were located around the center of Tirana were treated more carefully regarding their design (Figure 1). These dwellings were designed to fit the socioeconomic status of their dwellers since they were the elite of the socialist society. Other factors that make the selected case studies rely on higher quality features, from the location in the center of Tirana, were spatial features and more qualitative exterior materials (Manahasa, Ozsoy, & Manahasa, 2021). The selected housing buildings were: the *"Nëntë Katëshet"* residential complex, an apartment block designed by Ibrahim Prushi *("Kafe Flora"),* an apartment block designed by Maks Velo ("Pallati me Kuba"), *a* residential complex designed by Faik Alimehmeti and a residential complex designed by Petraq Kolevica. The study uses volumetric composition, indoor spatial features, and existing outdoor spaces to analyze the architectural features.

Figure 1. Tirana city center and the locations of the selected case studies.

3.1. "9 Katëshet" Apartment Blocks

The "9 Katëshet" residential complex is located on "Barrikada" street. It consists of three 9-story high housing blocks, which also give the name to this residential complex. The buildings were constructed in 1983 and were designed by architects Faik Alimehmeti and Ibrahim Prushi. Their volumetric composition combines three triangular towers connected via smaller curvilinear volumes. Each tower has six apartments, except for the ground floor, which is designed for commercial purposes (Figure 2, 3 and 4). Similarly, the connecting curvilinear volumes are commercial and connected on the ground floor with the towers. The towers' facades partially are cladded with terracotta. The complex was recognized as the one where most state officials lived (Tashi, Dhrami, & Thomai, 2017).

The indoor spatial configuration of the triangular towers is organized around the core. The core of each building consists of a naturally lit polygonal staircase and an elevator, including six apartments on each floor, three 1+1 apartments, and three 2+1 apartments (Figures 2 and 3). The apartments are organized with a corridor that provides access to the other spaces. The kitchen in all apartments is treated semi-separated and is not entirely divided from the living room. The bathrooms have natural light and ventilation.

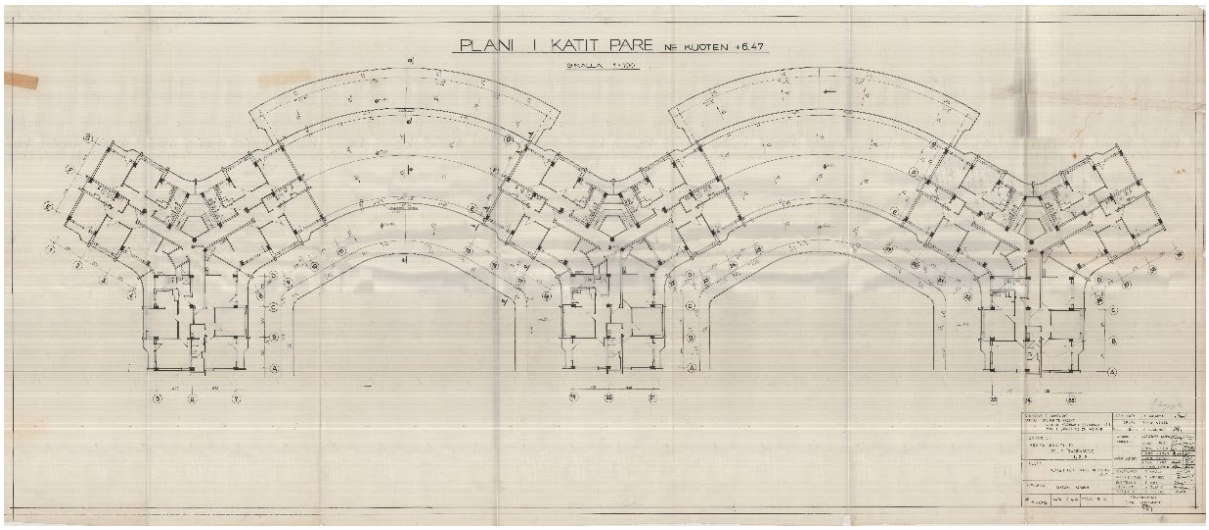


Figure 2. Ground floor plan of "9 Katëshet" Residential Complex (AQTN).

Figure 3. Plan Scheme of one of the Apartment Blocks (left-AQTN) and (right) View of the "9 Katëshet" Residential Complex.

Figure 4. 3D Visualizations for "9 Katëshet" Residential Complex (Berenis Karamuca©).

Regarding the outdoor area of this neighborhood, the presence of trees and a few benches are noticeable, creating common shaded spaces for the residents to pass the time. Different commercial functions on the ground floor and the wide sidewalks attract people and invite them to interact, making the neighborhood appear lively and giving a sense of security. Due to the central location of the residential complex, there are not many parking spaces available for the residents. The proximity of the buildings to the main street causes air and noise pollution. However, the large trees between them also serve as a noise barrier.

3.2. Residential Complex by Faik Alimehmeti

This residential complex is located behind the National Historical Museum. The buildings were designed by architect Faik Alimehmeti and constructed in 1981 (Figure 6). The complex`s volumetric composition features two linear apartment blocks that unified form an “L” shape. These two buildings that make up this complex both have six floors. The largest building is made up of three cores, which have four apartments on each floor. The façade has many details, and the use of different materials can be noticed. The façade of the ground floor, which serves commercial purposes, is cladded in local Gjirokastra stone. The residential floors mainly have brick cladding façade except for the plastered walls of the balconies (Tashi, Dhrami, & Thomai, 2017). Also, the balcony parapets are designed with semi-rounded shapes (Figure 7).

The indoor spatial configuration of one of the housing blocks includes three cores (Figure 5), which are featured by naturally lit stairs. Each core has four apartments, two 1+1 and two 2+1 apartments. Apartments are entered through a corridor that leads to all the other spaces. The kitchen in all the apartments is unified with the living room. It is slightly shifted to create the illusion of a partially connected space (Figure 5).

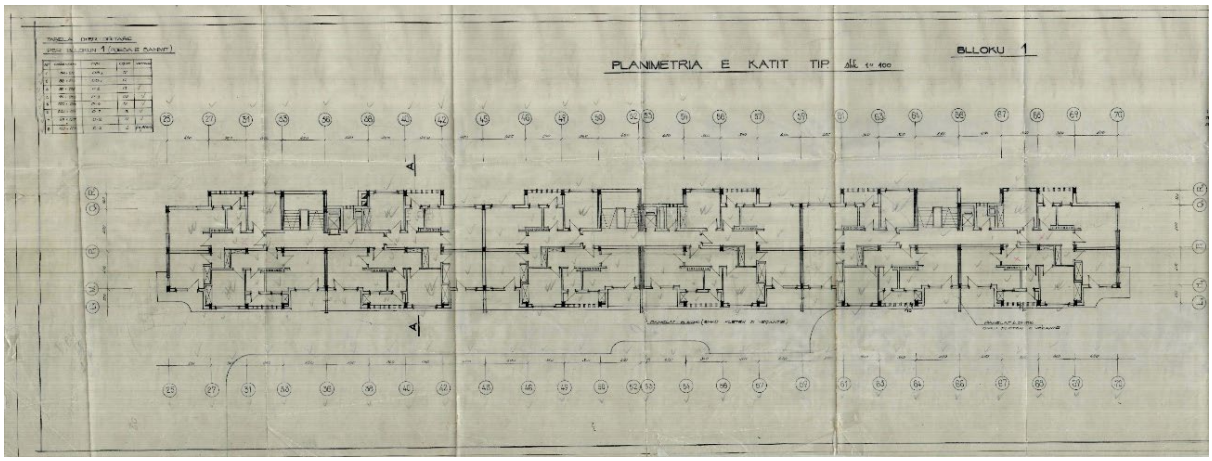


Figure 5. Typical Floor Plan of One of the Apartment Blocks of Residential Complex by Faik Alimehmeti (AQTN).

Regarding the outdoor area of this residential complex, the presence of trees and greenery is quite distinctive compared to other buildings. The presence of trees that also serve for shading is followed by many benches and sitting areas, creating a calm and peaceful environment. On the ground floor, there are commercial functions, especially cafes or restaurants, which generate a neighborhood atmosphere and provide a safer environment. The main road in front of the residential complex does not allow the residents to have many parking spaces. Even though the presence of the street near the buildings may appear concerning about the noise and air pollution as well as the safety, the green areas followed by a wide sidewalk can act as a noise barrier as well as a transition area which provides a kind of separation, privacy, and security for the dwellers.

Figure 6. Current Image of Residential complex by Faik Alimehmeti (Berenis Karamuca©).

Figure 7. 3D Visualization of Residential Complex by Faik Alimehmeti (Berenis Karamuca©).

3.3. Residential Complex by Petraq Kolevica

This residential complex is located in front of the National Bank. It was constructed in 1962 and designed by architect Petraq Kolevica. This residential complex is treated as an urban ensemble and consists of four apartment blocks, which are five floors high. Although this ensemble has a polygonal shape, the front block is designed with a soft curvilinearity. The ground floor serves commercial purposes, whereas the upper floors are residential. The layout of the buildings creates a rectangular courtyard with openings that create pedestrian access. The façade is minimalist, plastered, and dominated by a horizontal character (Figure 9 and 10).

The main apartment block's indoor spatial configuration consists of three cores providing access to four 2+1 apartments with a balcony. The stairs of the buildings are naturally lit, except in one of the buildings. The apartments` spaces are entered through a small corridor. The kitchen is not divided from the living room, except for two apartments on the floor. Only four out of twelve apartments have naturally lit and ventilated bathrooms, which are equipped with bathtubs here (Figure 8).

There are two outdoor spaces in this residential complex. The first one is the residential complexes` front part on the sides of the main road. In contrast, the second part is the courtyard between the buildings. On the one within the courtyard, there are more trees. This part of the outdoor area is more private since the entrances to the buildings are located on that side, and there are not so many commercial spaces. The courtyard allows for the residents to have some parking spaces.

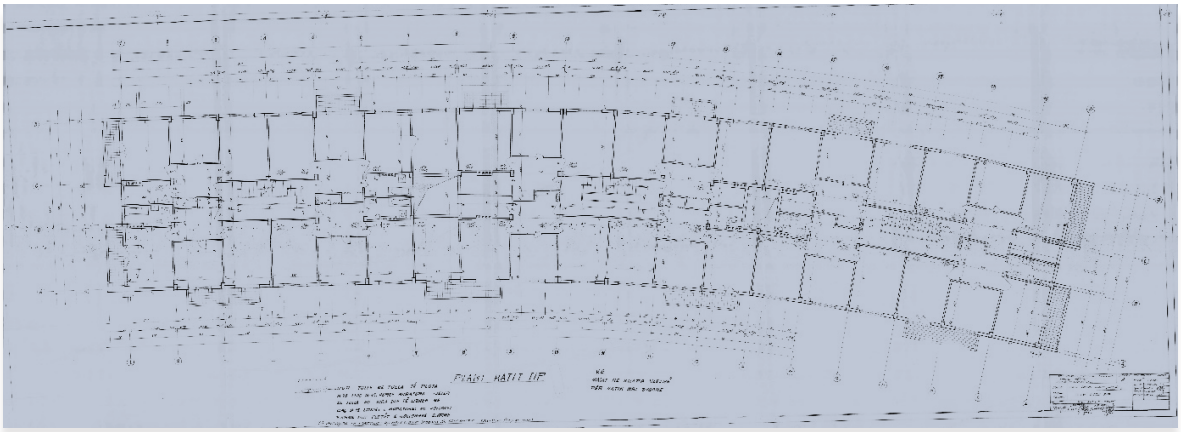


Figure 8. Typical Floor Plan of One of the Apartment Blocks of Residential Complex by Petraq Kolevica (AQTN).

Figure 9. View of Residential Complex by Petraq Kolevica (Berenis Karamuca©).

Figure 10. 3D visualization of Residential Complex by Petraq Kolevica (Berenis Karamuca©).

3.4. Apartment Block by Ibrahim Prushi

This apartment block is located at the connection between Durrësi Street and Mine Peza Street and was designed by architect Ibrahim Prushi. It has a sort of "V" shape, conditioned from the site (Figure 11). The apartment block consists of three cores, each containing two apartments per floor, while its height fluctuates from 4 to 7 stories. The ground floor is designed for commercial purposes, whereas the upper floors are residential. The façade of the buildings reflects purist architecture, is plastered, and possesses rectangular window frames (Figure 12).

The indoor spatial configuration of this apartment block possesses three cores, whose stairs are all naturally lit and provides access to two 2+1 apartments. The apartments are organized with a corridor that leads to the other spaces. The kitchen and the living room are not separated. The bathroom is featured by natural ventilation.

The outdoor spaces are very limited due to the housing position close to the street. There are trees on the lateral street sides of the building, whereas, in the front part, apart from trees, there are benches as well. Different commercial functions are located on the ground floor, including a famous café from which the building is called "*Kafe Flora*". The two busy streets passing by the building and these commercial functions attract more people and make the ground floor appear lively. The sidewalks are wide enough for people to pass by without bumping into each other, and biking lanes are also present.

Figure 11. Partial Plan of Apartment Block by Ibrahim Prushi (left-AQTN) and its view (right).

Figure 12. 3D Visualization of Apartment Block by Ibrahim Prushi (Berenis Karamuca©).

3.5. Apartment Block by Maks Velo

This apartment block, known as the "palace with cubes," is positioned along Dibra Street. It was designed in 1972 by architect Maks Velo. Among the others, it is recognized as the palace of writers since there used to live important Albanian writers like Kadare or Agolli. The residential building consists of 6 floors; the ground one serves for commercial purposes, and the upper ones are apartments. The building has two cores, each possessing two apartments per floor. The floor layouts are different, and these differences are reflected in the façade (Figure 15). The first, third, and fifth floors have an identical plan scheme, whereas the second and fourth floors have different ones. Due to the utilization of the cubist facade features, which were interpreted as a capitalist artistical influence during the socialist regime, architect Velo

was persecuted. The building`s exterior is treated with rough plaster finish, whereas the original ceramic tiles used in the balcony`s parapets are removed during the renovation conducted in 2021 (Figure 14).

This apartment block`s indoor spatial configuration consists of two cores with naturally lit stairs, providing access to two 2+1 apartments. The apartments` entrance leads to the other areas. The kitchen is slightly shifted to create a partially separated area. Among the others the rationality expressed in plans, reflects at the same time a spatial "nobility". Each apartment has a balcony and a storage space. The bathroom is featured natural ventilation (Figure 13).

Regarding the outdoor area of the apartment block, due to its location close to a main road, it possesses a narrow sidewalk on the front façade. It is featured by a low number of trees planted. The sidewalk in the rear façade is wider than in the front, although the presence of trees is limited, and no benches are found. The absence of green and sitting areas outside the building can be compensated by the fact that there is a park across the street.

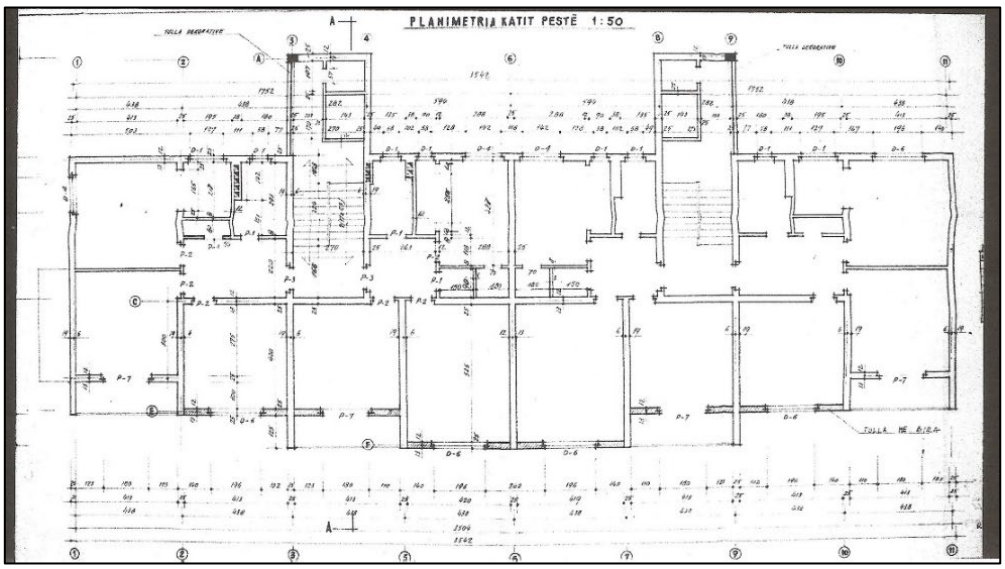


Figure 13. Plan of Apartment Block by Maks Velo (AQTN).

Figure 14. Image (after renovation) of Apartment Block by Maks Velo (Berenis Karamuca©).

Figure15. 3D Visualization of Apartment Block designed by Maks Velo (Berenis Karamuca©).

4. CONCLUDING REMARKS

This study provided an observation on the upper-class socialist period multifamily housing by analyzing their volumetric composition and indoor spatial and outdoor spatial features. Of the selected five case studies, three are conceptualized as residential complexes (*"Nëntë Katëshet"* residential complex, the one designed by Faik Alimehmeti, and a residential complex designed by Petraq Kolevica). In contrast, two are apartment blocks (palace with cubes designed by Maks Velo & the other designed by Ibrahim Prushi *(Kafe Flora).* Obviously proportionally related to the dwellers' socioeconomic status, the architects have used much freer forms in their volumetric compositions, when compared to the periods` design standards. This morphological freedom in their design is manifested through curvilinearity in the residential complexes, whereas in the apartment blocks, it is reflected through volumetric expressiveness. In the case of the *"Nëntë Kateshet"* residential complex, there is observed usage of tower apartment block, which is unique for socialist period Tirana housing.

The indoor spatial organization of residential complexes is designed with three cores, except in the "Nëntë Kateshet" residential complex, where only one polygonal core is seen. In the case of apartment blocks, the one designed by Maks Velo possesses two cores. In contrast, Kafe Flora multifamily housing includes three cores. Obviously, in the case of *"Nëntë Katëshet,"* the residential core of the towers is larger, consisting of long corridors. Apart from stairs, it also includes elevators, which were not usual for the period. The exteriors of the buildings are cladded with local terracotta in this residential and the one designed by Faik Alimehmeti, whereas the others are plastered.

The residential complexes possess common outdoor spaces, which feature greenery. The green spaces of the residential complex designed by Petraq Kolevica and the one by Faik Alimehmeti are qualitative and possess trees, bushes, and benches. However, in the case of *"Nëntë Katëshet"* although they possess public space, it is featured only by trees without greenery and used for commercial activities. The same cannot be said for the apartment blocks in this study. Due to being housing blocks located aside the street, they possess limited number of trees. Further studies regarding socialist period upper-class housing can be done to assess the quality of such typology. The authors acknowledge the limitations of not providing the plan schemes of all apartment blocks, since they had partial archival access to the drawings of two of the residential complexes and to one of the apartment blocks, that were subject to this research.

REFERENCES

[1] Aliaj, B. (2003). Albania: A short history of housing and urban development models during 1945-1990. The International Conference ENHR, the European Network of Housing Research, (pp. 24-45). Tirana.

[2] Bego, M. (2009), Skeda arkitekture: 1965-2004; ne kroniken e nje jete te dallgezuar. Monografi: Çeshtja e strehimit ne periudhen e socializmit real, [Mauricio Bego], Dea, Tirana.

[3] Bleta, I. (2010). *Influences of political regime shifts on the urban scene of a capital city case study: Tiran* (Master Thesis, Middle East Technical University).

[4] Bushati, V. (2012), Vilat e Tiran€es: gjysma par€e e shekullit XX, Polis Publications, Tirana.

[5] Godoli, E., Bendetto, G., Giuliano, G., & Ricci, G. (2008). The Presence of Italian Architects in Mediterranean countries. Firenze: Maschietto Editore.

[6] Islami, G., Veizaj, D., & Verdnani, G. (2018). The morphosis of Albanian socialist cityscape. A reaction to buildings with high-energy consumption. Ri-Vista, 52-63. doi:DOI: 10.13128/RV-24894

[7] Manahasa, E. (2017). *Place attachment as a tool in examining place identity: A multilayered evaluation through housing in Tirana* (Doctoral dissertation, PhD dissertation, Istanbul Technical University).

[8] Manahasa, E., & Özsoy, A. (2020). Place attachment to a larger through a smaller scale: attachment to city through housing typologies in Tirana. *Journal of Housing and the Built Environment*, *35*(1), 265-286.

[9] Manahasa, E., Ozsoy, A., & Manahasa, O. (2021). A hierarchical definitional framework for heterogeneous context: housing typologies in Tirana, Albania. Open House International. doi: 10.1108/OHI-07-2021-0157

[10] Misja, V., & Misja, A. (2004). Veshtrim mbi situaten e banesave ne Shqiperi :analize krahasuese. Tirane: Akademia e Shkencave e Shqiperise, Instituti i Ekonomise.

[11] Ndreçka, O., & Nepravishta, F. (2013). The Impact of Socialist Realism Ideology in the Albanian Architecture from 1945-1990. UBT International Conference, 7. Retrieved from https://knowledgecenter.ubt-uni.net/conference/2013/all-events/7

[12] Tashi, P., Dhrami, K., & Thomai, G. (2017). Apartment Typologies in Collective Housing and their Integration with the Space between Buildings. *Anglisticum Journal*, 9-25.

Design Method Automation for Detached House Layout Optimization

Anisa Cenaj[1]*, Anna Yunitsyna[1]

[1]*Department of Architecture, Faculty of Architecture and Engineering, EPOKA University, Autostrada Tiranë-Rinas, km. 12, 1032, Tirana, Albania*
** Corresponding author: acenaj18@epoka.edu.al;*

Abstract

This research is about an automated computational design process for achieving satisficing spatial layouts across predefined parameters. The proposed method is based on computational algorithms integrating human-scale inputs to configure suitable spatial configurations using python programming. Here we illustrate the configuration of detached house system, a hall and essential room's relations to each other. The hall remains stationary, whereas the spaces performs a closed loop around it considered as a stationary point. While there are different approaches for defining the travelling distance, the different combinations of several spaces regarding the vertical and horizontal travelling distance are calculated based on the centroids of the shapes involved. The algorithm comprises a trial-and-error layout generation method based on filter criteria for selecting among options based on Albanian design standard. The method is illustrated through mathematical equations and code development. The graphical interpretations of the results on the generative layout automation are prepared in Tkinter, a compelling graphical user interface (GUI) used by the python package. Hence, the overall process is automated to provide a favorable solution in as few steps as possible under time constraints. The proposed generative design constantly enables the user to interact with it from an early design stage. Moreover, it illustrates the interconnectivity between different computational tools and techniques for a participatory feedback loop across interacting actors like designers and non-designers.

Keywords: *Architectural Design Optimization, Spatial Layout, Detached House, Generative Design, Python Programming Language.*

1. INTRODUCTION

Generative design (GD) systems for space layout planning refer to computational methods to assist architects and designers in generating and optimizing building layouts. These systems use algorithms to simulate multiple design scenarios and assess them against a set of predefined parameters. Unlike traditional design methods, which rely heavily on human intuition and trial-and-error approaches, GD systems automate the design process and enable designers to explore a vast range of design options quickly and efficiently. Spatial configuration is in the same line as all physical design problems; hence it is considered a significant part of the investigation [1].

Additionally, spatial allocation can help professional designers to reduce the time and cost involved in the design process. By automating the generation of design options, architects can focus on evaluating and refining the most promising layouts rather than spending time drawing multiple alternatives manually. Many researchers agreed that computer automation is efficient in terms of time consumption and productivity [2].

Developing a code that generates and provides design solutions has challenged architects and professionals in computer programming [3, 4, 5, 6, 7, 8]. Designing an architectural plan is subjective; however, necessary criteria must be met during the process. It was reported by different researchers that these criteria sometimes crash while validating the generative design layouts [9, 10, 11, 12, 13]. For this reason, different researchers have proposed several algorithms and techniques to conduct the automation plan layout while involving a wide list of constrains. If properly set up in the algorithm, these criteria not only provide good plan layouts but also minimizes the computational cost in terms of time.

This research aims to prepare an automated design method through a computer approach to generate several, different and well-organized floor plan layouts considering Albanian Design Standard. It focuses on computational algorithms that integrate human inputs to configure suitable layouts and specific values based on previous research studies. Throughout the study it is shown a detailed literature review focused on the main constraints to be validated while automatically generating the layouts. Furthermore, a methodology on the development of suitable algorithms while adopting these constrains in a user friendly and easy programming language is demonstrated.

The entire algorithm is written in Python programming language [14] which is selected as suitable and easy tool for architects. Python is selected as a high-speed execution package among many programming languages, significantly affecting time efficiency. Furthermore, the python package is provided for free, so the algorithms presented in this study can be tested by all interested researchers. The final outcome is a graphical user interface GUI prepared in Tkinter for user interaction and visualization [15].

2. MATERIALS AND METHODS

In this study a detailed methodology for generative design of a detached house is presented. This is a promising approach for architects and designers seeking to optimize the use of space and generate well-balanced and functional designs. The spaces that are taken in consideration for the development of the generative design procedure are essential for representing a detached house model and are as follows: Living room, Kitchen and Dining, Bathroom, Bedroom and a Hall. The hall will function as a stationary point during the entire process as it refers to a starting position for the generative design algorithm. The rooms perform movements in a closed loop around the hallway, using the geometric centroid to determine their arrangement. Once the essential rooms have been identified, the algorithm involves designing each room in a way that meets its specific function. This process is carefully based on a set of rules to ensure that the house is functional, aesthetically pleasing, and provides a comfortable living space for the homeowner.

The number of spaces is the first criterion in this phase that is taken into consideration when developing the generative design algorithm. The process starts with the determination of spaces to be arranged in the plan layout using automation procedure. By allowing the user to determine the number of spaces, the algorithm provides a personalized approach to generative design that meets the user's specific needs and preferences. In addition, defining the motion path is necessary when using the centroid method, as it requires the spaces to move in a closed loop around the hall. For each arrangement position there are computed X and Y coordinates in horizontal and vertical axis. Figure 1 shows the possible movements for the room’s vertical and horizontal travel distance based on the centroid of each shape involved.

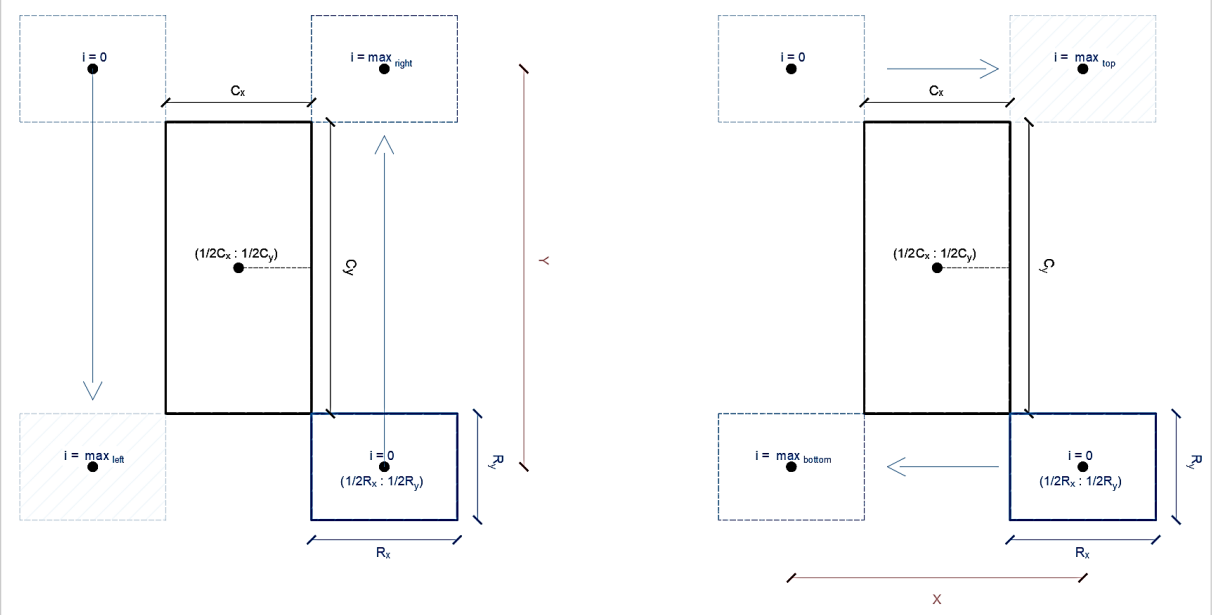


Figure 1. Vertical (left) and horizontal (right) possible movement of the room around the corridor

The equation which would adequately determine the location of the room regarding the centroid of the Hall would be as shown below:

$$X = Cx + ½\,Rx + ½\,Rx \quad (1)$$
$$Y = Cy + ½\,Ry + ½\,Ry \quad (2)$$

Where: C_x is the width of the Hall, C_y is the length of the Hall, R_x is the width of the room $_i$ and R_y is the height of the room $_i$. These two equations are written in Python to generate all possible coordinates for the position of the room. The incremented distance between each of the steps of the movement is specified as 5cm.

The preliminary set of coordinates demonstrates a 360-degree movement around the hall in every direction. However, the algorithm must be adopted according to the architect's conceptual design and logical cases. For instance, a room $_i$ cannot be positioned in the corner of the Hall as it does not maintain a minimum required space connectivity distance. Hence, in order to ensure that each space loops around the hall in a functional way, a distance corner constraint based on doorways is implemented. This means that each space will have a corner constraint that includes a minimum of 100 cm width sharing wall between Hall and other spaces for communication purposes. In figure 2 this constraint parameter is represented by label "a".

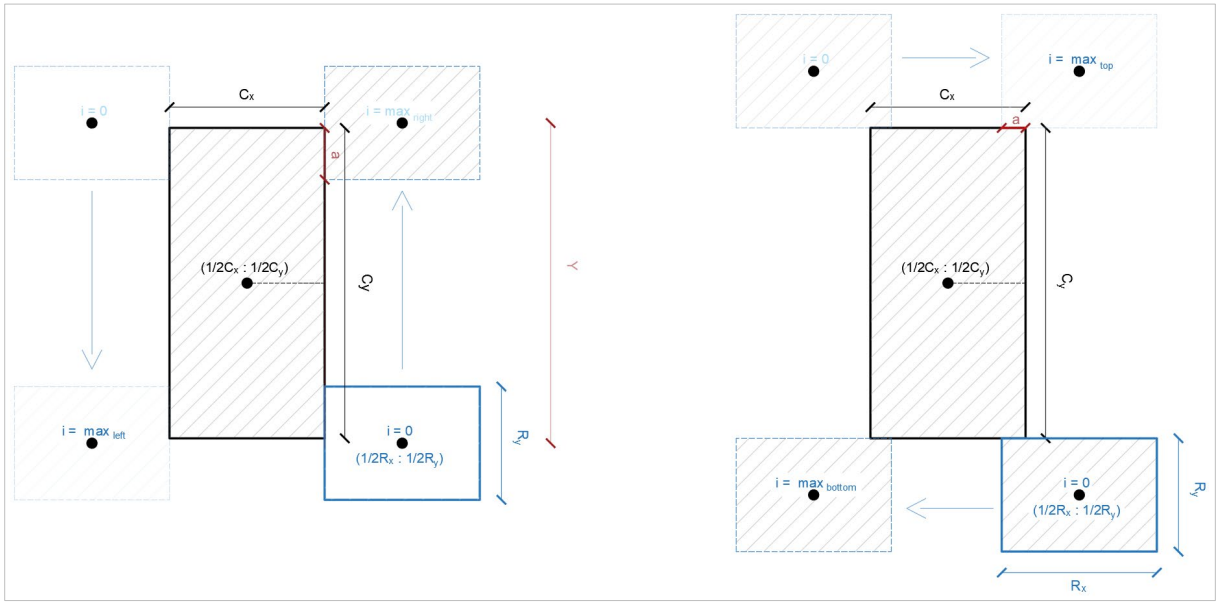


Figure 2. Vertical (left) and horizontal (right) possible movement of the room around the Hallway, avoiding corners to ensure sufficient passage between spaces

Therefore, the equation of the motion coordinates would change by integrating the corner constraint, as shown below:

$$X = Cx + ½\,Rx + ½\,Rx - 2a \quad (3)$$

$$Y = Cy + ½\,Ry + ½\,Ry - 2a \quad (4)$$

The modified equations must be included in several calculations to define all the coordinates needed. For this step, a repetitive loop will be written in python programming language. The algorithm is developed in the environment of python version 3.7, whereas for the graphical user interface, the powerful Tkinter library is utilized. Using Equation 3 and Equation 4, a set of coordinate values is generated. These coordinates are later used to define the position of the room concerning its center of gravity. The repetitive coordinates are generated using "for loops" in Python. The range of the loop is set by using the equation.

$$coordinate_i = \frac{Travel\ distance\ in\ \boldsymbol{x}\ or\ \boldsymbol{y}\ direction}{step\ distance} \quad (5)$$

Where: coordinate i is the coordinate at a position step, and step distance is the 5 cm distance used to move the room to another position. Two loops are initially utilized for accomplishing this step: one for horizontal coordinates and one for vertical ones. As there are two sides on each axis, a third loop is used to take the control of the direction coordinates. The schematic view of the coordinate calculations would be as shown in Figure 3.

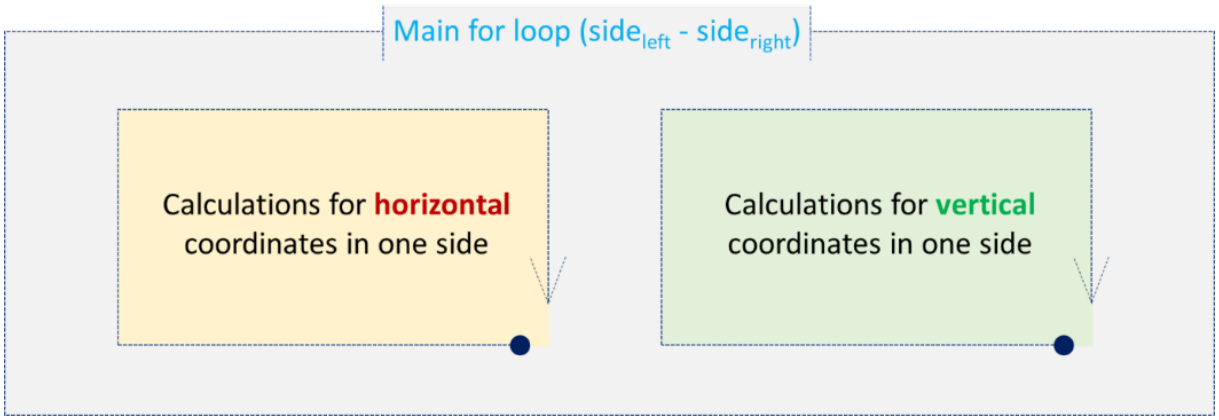


Figure 3. Hierarchy of loops used to calculate the coordinates of each position of the room around the Hall.

In addition, when designing a layout plan, it is essential also to consider overlapping constraints to ensure that the space is utilized efficiently. Overlapping constraints refer to the limitations or requirements that arise when two or more elements in the layout need to occupy the same physical space. The challenge in addressing overlapping constraints lies in finding ways to prioritize the different requirements without sacrificing functionality or aesthetic appeal. Successful generative plan layout design involves balancing these constraints to generate a cohesive and efficient design that meets the needs of the space and its occupants.

Based on building guidelines as well as architectural suggestions, the location of the spaces must be set to maintain its functionality. This is done by considering the north, east, west, and south directions for each type of room, in accordance with Albanian standard building code [16]. In terms of algorithm perspective these parameters will be categorized as additional constrains which at the same time will reduce the number of inefficient plan layouts.

As each of the projects requires a specific budget not to be exceeded which does mainly relates with the area of the building, another important function to be integrated in the algorithm will be the maximum allowable area of the floorplan. In this study this parameter is presented as additional constrain and is specified by the user based on the requirements of the owner. By setting this limit, the algorithm can generate a design that is both functional and within the user's desired overall area. Further to the maximum allowable area constraint, the algorithm also takes into account the minimum dimensions of each space based on local building standards of Albania [16]. These standards specify the minimum size requirements for each type of room in a detached house. By adhering to these standards, the algorithm can generate various plan layout designs in compliance with architectural aesthetics, godliness within the permissible user requirements.

3. RESULTS AND DISCUSSION

A simple application of generative design automation is prepared and presented in this paper using python programming language and a set of architectural criteria and rules. The methodology is presented in terms of mathematical calculations and code development. The final product is an application window prepared with a graphical user interface. The graphical user interface (GUI) is prepared in Tkinter, and a python library is developed for interface and interactivity between user and algorithm.

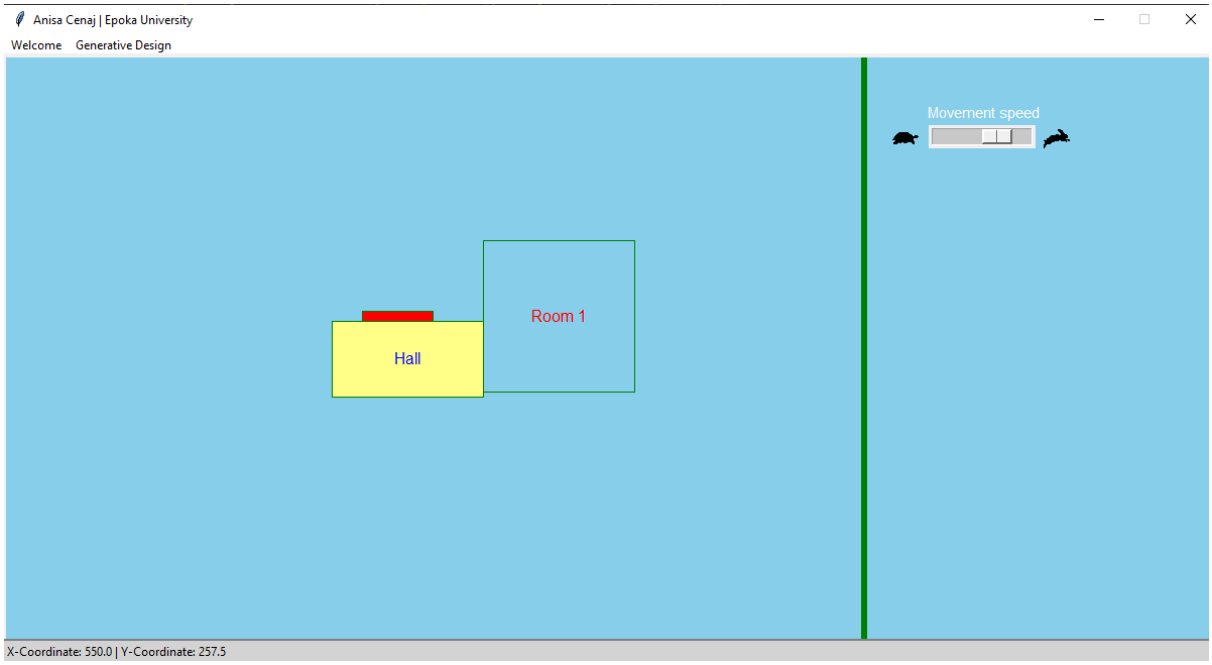


Figure 4. A Graphical User Interface (GUI) prepared for demonstration.

As shown in Figure 4, the GUI simulates existing software configurations ready to be used. The main window prompts with a bar at the top, providing users with sufficient options to use the application. In addition, the central region of the window is cascaded into two parts. The left part presents the generative design simulations, which the user controls. The right part provides a panel of inputs so the whole design process can be customized according to the preferences of the Architect. Additionally, the last part of the window is comprised of an end bar at the bottom region, which shows the motion coordinates of the rooms while compiling the simulations.

Furthermore, the user can modify the hall dimensions, room dimensions, the corner distance to be skipped, the front door dimensions, its location from the corner and the position such as north, east, west and south. However, the current study provides all default values imported from local design standards. The GUI also provides the speed control during the simulations. Controlling the speed of movement means that the user can quickly check how accurate the code is in specific regions where a constraint is defined. This facility is defined at the top bar as "Initialize Normally". In addition, another option is provided, which completely removes the delays for each step simulation and runs at max speed. This option saves time and checks how fast Python can execute the code.

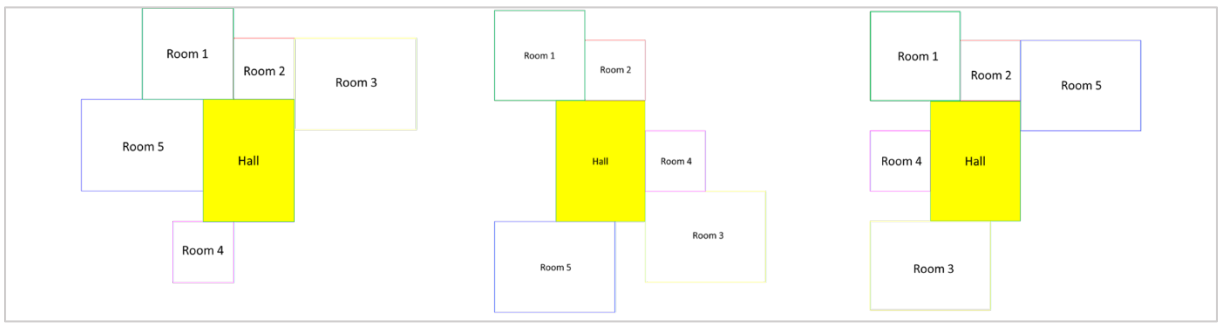


Figure 5. Manual selection of 3 out of 163,000 raw plans generated by GD method.

Finally, conducted tests show that each of the criteria and rules is adequately defined and implemented by the script. The coordinates match according to hand calculations before preparing the motion equations. The accuracy of the algorithm seems to be satisfactory. The execution of the functions also results to be in maximum speed. Hence, this application can be helpful for a significant group of users, including architects and other interested parties. A real case example of 6 spaces detached house is performed and demonstrated in figure 5. Out of 163,000 plan layouts generated, in the figure 5 there are manually selected and presented 3 of them.

Nevertheless, the selection of the plan layouts must be done using fitness functions for a better validation. Hence, the code can be improved by extending the methodology and adding more phases of algorithm to filter the best plan layouts. Furthermore, the exportation of plans to AutoCAD software is another milestone to be accomplished.

4. CONCLUSION

In this paper a methodology is presented to successfully implement generative design method for a detached house. The algorithm prepared is based on the space centroids by initializing the entire process from a stationary point which is represented by the centroid of the hall. By implementing adequate calculations and developed formulas, the motion path of each spaces around the hall generated for an increment step of 5 cm to achieve higher accuracy. To avoid incorrect plans and satisfy the architectural rules and suggestions, a list of constraints is defined and implemented in algorithm. The algorithms are written in python programming language, selected as an easy, user-friendly and fast processing tool. The final output, which is presented in a GUI, demonstrated thousands of raw plan layouts which confirm the accuracy of the algorithm, consistency and non-clashing constrains. The study can be improved more by filtering each of these massive outputs using fitness functions as suggested in literature.

REFERENCES

[1] Victor Calixto, Gabriela Celani, "A literature review for space planning optimization using an evolutionary algorithm approach: 1992-2014," in *XIX Congresso da Sociedade Ibero-americana de Gráfica Digital 2015*, 2015.

[2] M. Jauregui-Becker, "On the Definitions of parametric Design Problems for Computational Synthesis," in *International Conference on Engineering Design, ICED'07*, Paris, 2007.

[3] D. El-Zanfaly, "Design by Algorithms: Generative Design System for modular Housing Arrangment," *CAD Projeto Assistido por Computador,* pp. 65-67, 2009.

[4] Agnieszka Sowa, Ludger Hovestadt, ""Decission Support in Architectural Strategic Planning: Towards a Volumetric Modelling of Solution Strategies in Investments Planning," *eCAADe,* pp. 203-210, 2011.

[5] C. Pradal, F. Boudon, C. Nouguier , "A Python-based geometric library for 3D plant modelling at different scales," *Graphical models (Elsevier),* pp. 1-21, 2009.

[6] Regiane Pupo, Érica Pinheiro, Gelly Mendes, Doris Kowaltowski, Gabriela Celani, "Generative Design Systems for Housing: An outside-in approach," *eCAADe,* pp. 501-506, 2011.

[7] C. Soddu, "New Naturality: A Generative Approach to Art and Design," 2002. [Online]. Available: http://www.jstor.org/stable/1577119..

[8] Kristina Shea, Aish Robert, Gourtoviava Marina, ""Towards integrated performance-driven generative design tools," *Automation in Construction (Elsevier) ,* pp. 253-264, 2005.

[9] Machi Zawidzki, Kazuyoshi Tateyama, Ikuko Nishikawa, "The constraints satisfaction problem approach in the design of an architectural functional layout," in *Engineering Optimization*, England, Taylor & Francis, 2011, p. 943–966.

[10] Graziella Laignel, Nicolas Pozin, Xavier Geffrier, Loukas Delevaux, Florian Brun, Bastien Dolla, "Floor plan generation through a mixed constraint programming-genetic optimization approach," *Automation in Construction,* vol. 123, p. 103491, 2021.

[11] Xuejun Cao, Zhijun He, Yunhe Pan, "Automated design of house-floor layout with distributed planning," *Computer-Aided Design,* vol. 22, pp. 213-222, 1990.

[12] P. Svanerudh, "ARCHITECTURAL CONSTRAINTS FOR DESIGN AUTOMATION OF MULTI-STOREY TITN'IBER HOUSES," *Automation and Robotics in Construction,* pp. 181-186, 1999.

[13] SIU-PAN LI, JOHN H. FRAZER, MING-XI TANG, "A CONSTRAINT BASED GENERATIVE SYSTEM FOR FLOOR LAYOUTS," *CAADRIA proceedings,* pp. 417-426, 2000.

[14] G. v. Rossum, "Python tutorial, Technical Report CS-R9526," Centrum voor Wiskunde en Informatica (CWI), Amsterdam, 1995.

[15] F. Lundh, "An introduction to tkinter," 1999. [Online]. Available: Www. Pythonware. Com/Library/Tkinter/Introduction/Index. Htm..

[16] Fletorja Zyrtare e Republikës së Shqipërise, Tiranë: Botim i Qendrës së Botimeve Zyrtare, 2015.

Integrating Human Scale Developments in Large Scale Infrastructure: "New railway Durres-Tirana-TIA"

Arona Muja[1]*, Fabio Naselli[2]*

[1]*Department of Architecture, Faculty of Architecture and Engineering, EPOKA University, Autostrada Tiranë-Rinas, km. 12, 1032, Tirana, Albania*
** Corresponding author: amuja18@epoka.edu.al; fnaselli@epoka.edu.al;*

Abstract

Over the past centuries, urbanization and city growth have gradually altered the physical and socioeconomic landscape as well as the interactions between its natural, rural, and urban aspects. Because of advances in technology that allowed businesses to transform the landscape and the territory decisively using strong and globalized methods, this urbanization process has accelerated over the course of the last century as a result of an expansive economic structure. (Sassen, 2004) This thesis investigates the integration of human scale developments in large-scale infrastructure projects to reduce the use of top-down approaches. This approach has been criticized for putting the needs and concerns of the local community below efficiency and cost-effectiveness, leading to social and environmental issues. (Max-Neef et al., 1989) The study suggests incorporating human scale developments into significant infrastructure projects to address these problems. This strategy involves involving local communities in the planning and implementation process while taking their needs and concerns into account. Smaller scale infrastructure projects, like a bike line along the rail trajectory, are needed to address the needs of the local community. The study presents international and local case studies that illustrate the advantages of this strategy, including improved social and environmental outcomes, increased project sustainability, and greater community engagement. (Ibem, 2009) The study found that incorporating small-scale infrastructure projects can lead to more inclusive and environmentally friendly infrastructure development. A change in the current top-down approach to one that prioritizes community engagement and inclusiveness is necessary to effectively integrate human scale developments in large scale infrastructure. (Li et al., 2021) The local community will benefit from this strategy, leading to more resilient and sustainable infrastructure projects.

Keywords: *human scale, infrastructure, cycling networks, rail networks, inclusivity, community, transport.*

1. INTRODUCTION

The widespread use of personal vehicles has significantly changed the character of urban areas, causing uneven distribution, social disintegration, and environmental degradation. The expansion of car-centric urban planning, which resulted in the construction of highways, parking lots, and other car-centric infrastructure, has made this problem worse. Additionally, the car-centric approach to urban planning has accelerated the degradation of the environment in other ways, such as air pollution and carbon emissions. It is necessary to move toward sustainable, integrated urban planning that puts an emphasis on active mobility, public transportation, and compact, connected urban development in order to address these problems. Active railroad corridors are often considered as potential sites for trails due to their desirable characteristics, such as gentle grade, existing and maintained right-of-way, and connections between

communities or destinations. (Monsere et al., 2012) Bike lanes are becoming increasingly popular as more communities develop and expand their bicycle, pedestrian, and trail networks. Since the late 1990s, there has been an increase in public interest in using land near rail lines for public shared-use paths and trails. To address safety, capacity, and liability issues, railroads, trail developers, and communities must collaborate to build new railway lines. Bike lanes are a solution to traffic congestion, reduce carbon emissions, and enhance public health due to the growing demand for alternative modes of transportation.(Nadimi et al., 2021) This thesis examines the opportunities and potential effects of including bike lanes in the designs for a new railway line. It will examine the advantages of bike lanes alongside railway lines, such as increased accessibility and mobility, and lower carbon emissions. It will also examine case studies of bike lanes along railways from other countries, offering insights into best practices and lessons learned. Finally, it will look at the advantages of mini stops, such as improved accessibility, mobility, and economic growth.

Modern society places a lot of importance on infrastructure development, as it supports economic growth, enhances quality of life, and makes a variety of services operate effectively. However, it is important to approach these projects from a human scale perspective to ensure that they meet functional needs and improve the quality of life and liveability in the communities they serve. (Lee, 2010) The human scale approach can lead to the development of liveable, environmentally friendly urban areas with well-planned public areas and open green spaces, improving the quality of life for those who live and work there. It can also help to design the infrastructure to meet the communities' needs and long-term goals, making it more flexible and resistant to fluctuating demands. Additionally, it can help to develop inclusive infrastructure that meets the needs of various demographic groups, such as the elderly, young children, and individuals with disabilities. (Brömmelstroet & Bertolini, 2010) Incorporating a human scale approach into the development of large-scale infrastructure is essential for creating liveable, sustainable, and inclusive communities. By ensuring that everyone has access to the facilities and services they need, this can contribute to the development of a more equitable society. Infrastructure that meets their needs and enhances their quality of life can be developed by placing people at the center of the design process, contributing to a better future for all.

2. MATERIALS AND METHODS

This paper is the result of an in-depth investigation into both current and future rails-with-trails, as well as the project of the new railway being built in the Durres-Tirana Region. It included a review of the literature on railroad systems, documentation of local transportation analysis and ongoing research on Albania's rail system, and a literature review of published documentation, conference presentations, data collection, and analysis.

2.1. Rails with Trails

A "rail-with-trail" is a shared-use path or trail that is developed and made available for public use and is situated on or close to the rights-of-way of an operational railroad or rail transit corridor. It is fundamentally different from "rails-to-trails," which is the conversion of the entire right- of-way after all rail service has been terminated or abandoned. Trail users generally prefer to be separated from active rail lines, and active railroad corridors are frequently considered as potential locations for trails. However, private freight railroads forbid trails on their railroad right-of-ways due to the perceived safety risks to railroad workers and the general public, the elevated liability risk to the railroad, and the potential effects on future rail operations. Effective design strategies include regulatory requirements, setback, separation, at-grade crossings, and traffic control devices. Trails have the potential to benefit local communities in a number of ways, such as active transportation, health and wellness, access to jobs, services, physical activity, and outdoor recreation,

economic development, and protecting the environment. They should be planned with accessibility and safety in mind, and secure bicycle parking should be set up close to the stations to promote multimodal transportation.

2.1.1. Albanian Railway

The standard railway network in Albania is a relatively recent construction that started in 1947 and was completed in 1986 with the opening of the line from Shkodra to Hanii-Hoti on the Albanian border with Montenegro. 66 passenger wagons, 225 freight wagons, and 25 locomotives are currently in the inventory of Albanian Railway. The network consists of four primary lines: Durres- Tirana, Durres- Vlora, Rrogozhine-Pogradec, and Vore- Hani-i-Hotit. Two further branch lines complement it. 196 kilometers of the network is dedicated to passenger services, including the Tirana railway line to Durres, which was built in 1951 and renovated in 1996. Passenger service after crossing the city of Elbasan has temporarily been discontinued in Librazhd (22 km east). Services for freight transport are handled in: Shkoder - Hani i Hotit - 35 km, Budull - Fushe Kruje - 8 km, Fier - Ballsh - 25 km with a total length of 68 km. The majority of the country's railway network is located in the west, with the line from Elbasan to Pogradec serving major industrial hubs. Rail freight services are few in number, take a long time, and are not in high demand. The infrastructure is in poor condition due to lack of funds and damage caused by the riots in 1991 and 1997. The Albanian government and the Union European signed a Stabilization and Association Agreement in 2006, which calls for the restructuring of the Albanian Railways in accordance with EU standards. Alternative forms of transportation, such as buses and minibuses, have decreased the number of passengers using trains, and regional rail mobility should be utilized to manage flows and reduce environmental pollution.

2.1.2. New Railway Project

The absence of spatial plans and the failure to implement the legal framework are the main barriers to sustainable development in Albania, leading to urban dispersion. Urban dispersal has primarily taken place in the suburbs of Tirana and Durres, characterized by constructions from before 1945, constructions from the communist era, residential blocks, and apartment complexes. This has resulted in an uneven distribution of public services. In areas with high levels of economic development, such as Tirana, Durres, Kamza and Vora, the environmental situation has worsened due to rapid urban growth, a high volume of movement, and a lack of spatial plans. This has led to the development of villa complexes in the form of "closed communities" and encourages the expansion of cities and the use of cars. The negative effects of this development include increased infrastructure costs, loss of agricultural land fund, biodiversity damage, increased vehicle traffic, social segregation, and low property security. (Eco-Project, 2021) The Albanian National Transport Plan (ANTP) reveals that 61% of long-distance passengers take industry transportation, while 39% use private cars. Mother Teresa International Airport has experienced a significant increase in passenger and freight traffic, with 1,700,000 passengers and 11,000 aircraft movements per year. The spatial distribution of education services in the Tirana-Durres metropolitan area is affected by population migrations and demographic changes. High concentrations of high schools are found in Tirana and Durres, while there is a lower concentration in the suburbs. With the exception of the Agricultural University, state universities are mostly found in the area, and private universities are dispersed along the national highways. Accessible public transportation for students, lack of green spaces and public areas, pollution, noise, and proximity to traffic, and the absence of support spaces such as generating centers linked to the university as workshops, creative economic centers are all issues that affect the education sector. It is important to address these issues while also benefiting the field of education, where rail travel is highly favored and comfortable.

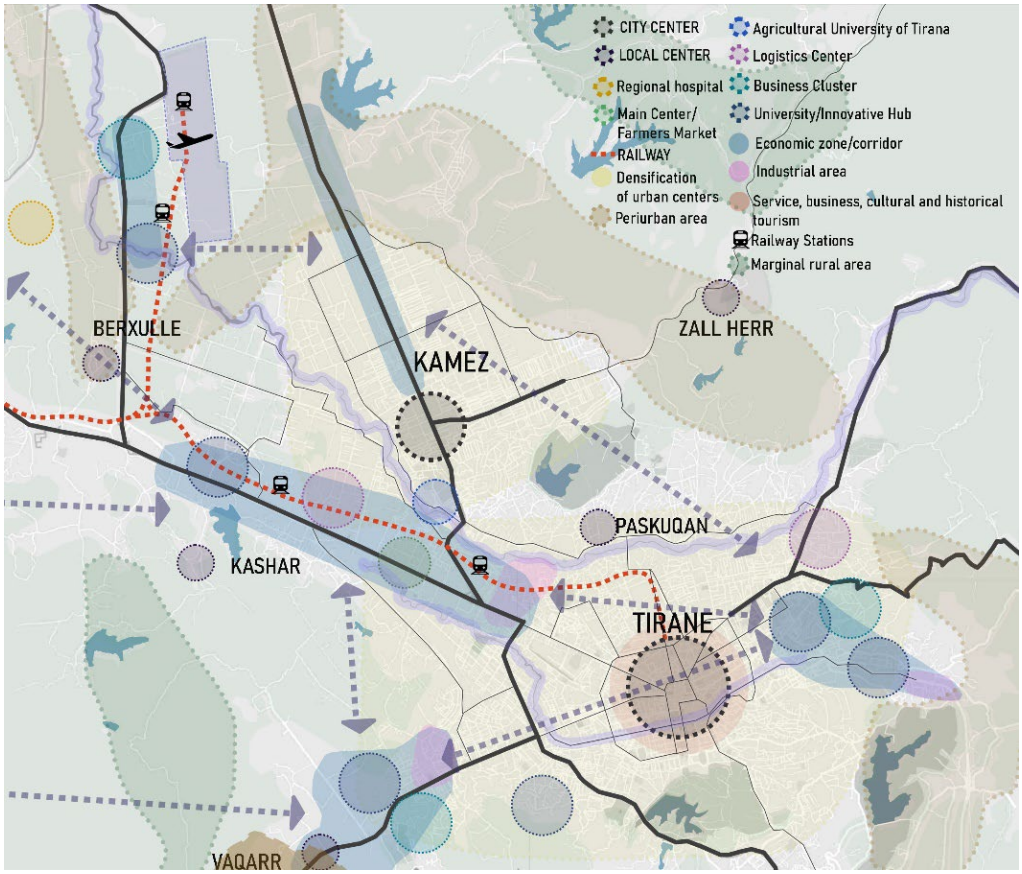


Figure 1: Demonstrative map of the new railway link and analysis of site character

The New Line to Tirana International Airport includes four stations and one railroad stop: Airport Terminal Station, University Rail Stop, Kashar Station, and Tirana PTT Station.The extension between KP-29 + 470 and KP 30 + 120 in Kashar is currently in use as a temporary terminal station for the Albanian Railway Network. In the project's final presentation, the current Kashar station will be expanded to include two additional lines in addition to the main one, as well as a central platform that is 150 meters long and a platform that is 100 meters long. It will act as a rail station for travelers, a resort spot for trains, and a support area for handling the Laknas cargo storage area. The PTT station in Tirana consists of the city's railway terminal and a multimodal center that includes equipment for trains, the planned Tirana tram network, and bus infrastructure. The terminal station project was developed in accordance with the institution's existing Master Plan and includes five primary railway lines, platforms and locomotive maneuvering lines for all kinds of trains, a central platform measuring 160 meters, and a platform 200 meters wide and 200 meters long for all train types. Every platform is wide enough to accommodate passenger transportation (escalator bridges and elevators).

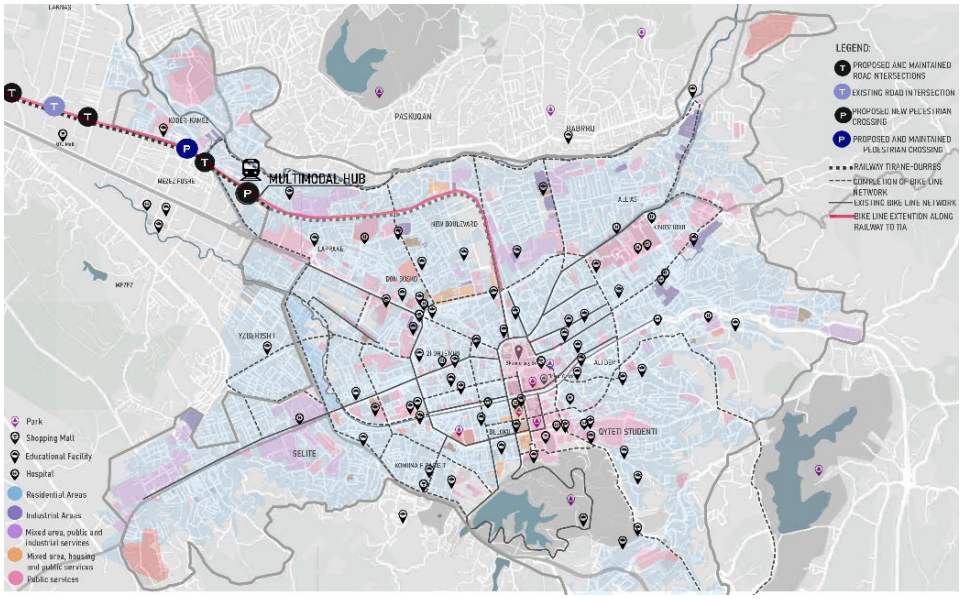


Figure 2: 1st Area of Implementation Characteristics (Tirana)

The urban planning and design of the center of Tirana has long been renowned as being car-centric. When planning the city's infrastructure, the primary focus was on private automobiles, which had a number of unfavorable effects. In recent years, the city has rapidly urbanized and become more motorized, with a corresponding rise in the number of vehicles on the road. As a result, the city's streets are congested, making it challenging for cyclists and pedestrians to move through the city. Railways that connect to the city center are essential for efficient transportation, accessibility, economic development, sustainability, and air quality. They provide a fast and efficient means of transportation for commuters and visitors, and make it easier for people to access jobs, education, healthcare, and other services in the city center. They can also help to revitalize neighborhoods by increasing access to jobs and services, and attract new businesses to the area, creating new job opportunities and boosting the local economy.

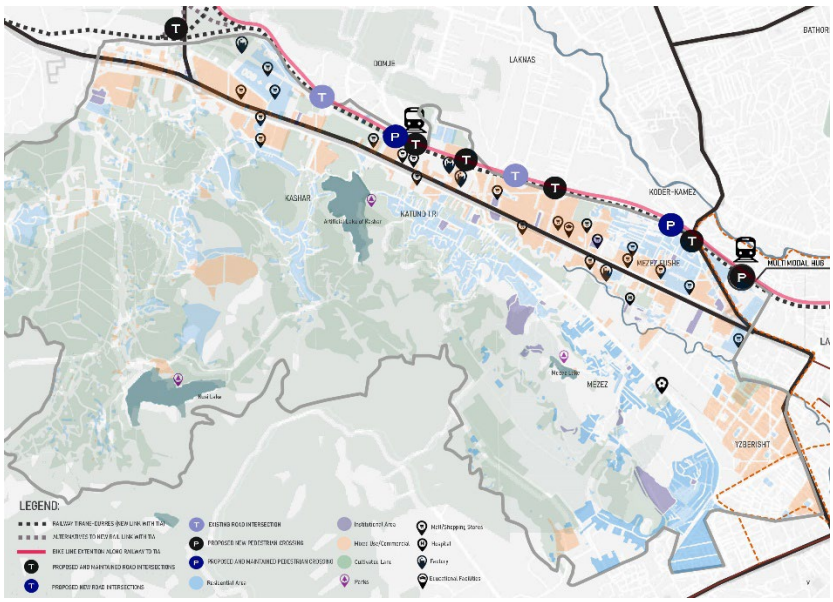


Figure 3: 2nd Area of Implementation Characteristics (Kashar)

2.1.3. Proposals and Design Plan

An exceptional opportunity to improve the connectivity and accessibility of communities along the rail track exists with the construction of new railway lines. A bike line and mini stops can be integrated to increase mobility and offer environmentally friendly transportation options. In order to improve connectivity and integrate communities, the proposal of bike line alongside a new rail line, as well as small stops along the way are introduced. Analyzing the potential effects and opportunities of incorporating a bike line and small stops along a new rail line is crucial to the implementation.

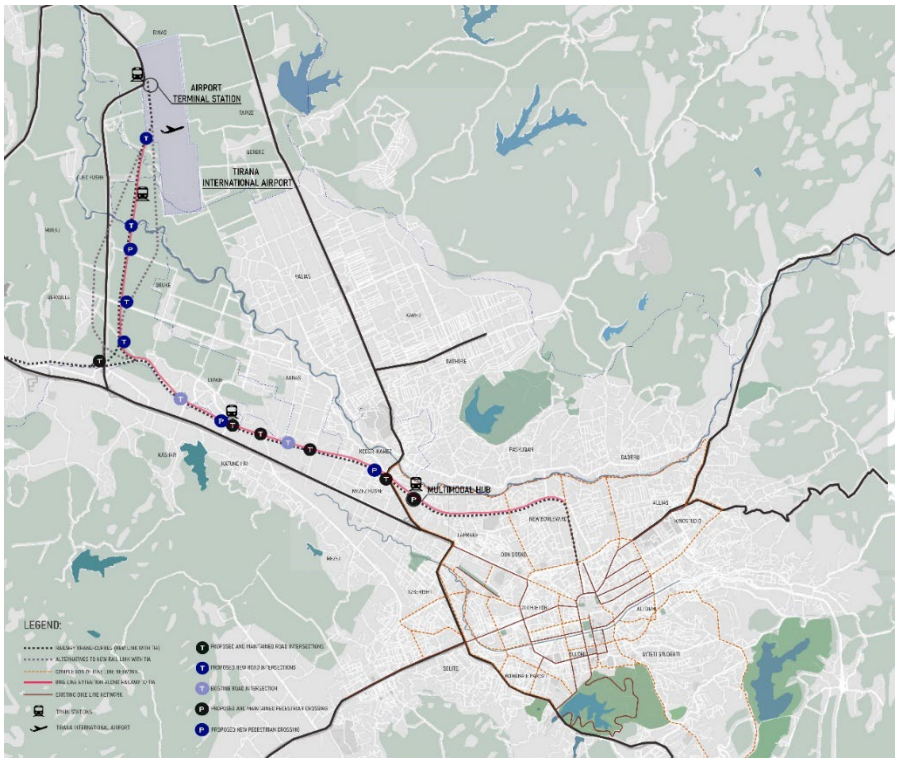


Figure 4: Proposed bike line alongside the railway (bike network in the city center)

For a city's transportation system to be effective, sustainable, and accessible, various modes of transportation must be connected. The city benefits from connections between modes of transportation for a number of reasons, including better accessibility, increased efficiency, better resource utilization, improved sustainability, financial gains, and higher property values. In addition to providing dedicated bike lanes alongside bus lanes, a well-connected bus and train system can help commuters avoid traffic on the roads and get to their destinations faster.

Mini-stops along the railroad with various characters are significant for a variety of reasons. They improve the effectiveness of the railway system, foster economic development, and increase safety for both passengers and railway employees while giving passengers easy access to key locations and services. They also aid in easing traffic congestion and enhancing traffic flow in general. They also assist in lowering the possibility of accidents and injuries in crowded urban areas.

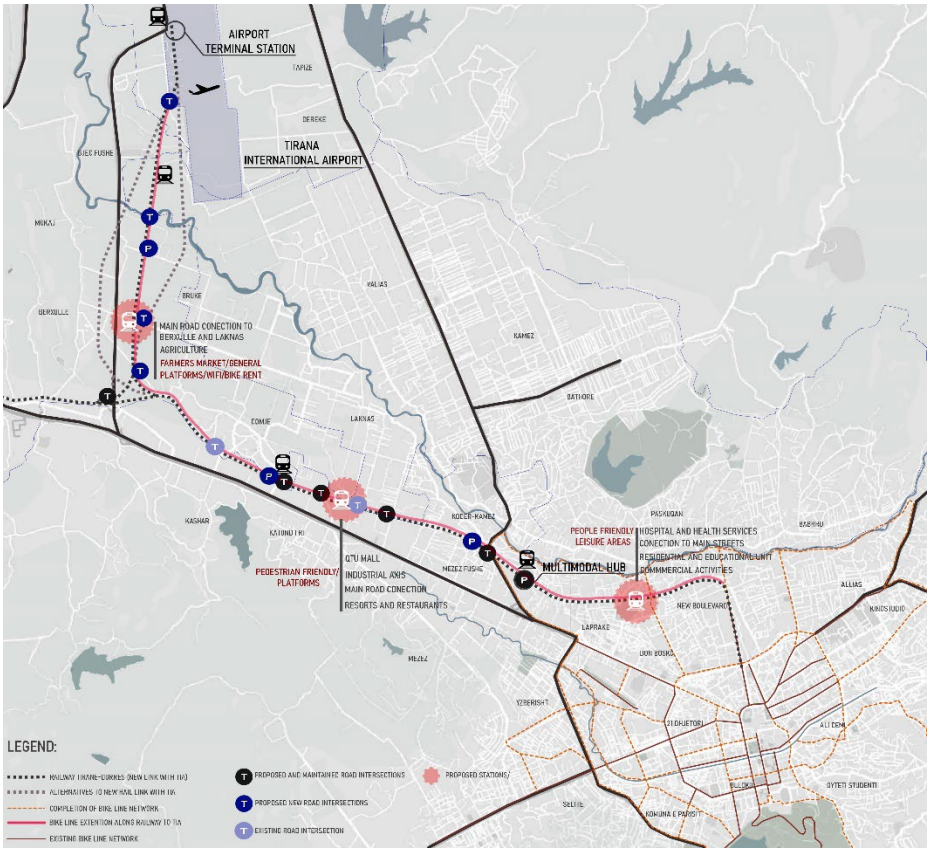


Figure 5: Proposed Stops on important nodes along the railway

The mini railway stop located in an agricultural area near Laknas and near the hospital in Tirana counts as an important transportation hub that serves both local residents and visitors to the area. It provides a convenient and reliable stop for people who need to access the hospital or travel to other destinations in the surrounding area. It also helps to support local farmers and other agricultural businesses by allowing them to more easily access the railway system and transport their goods efficiently and affordably. Additionally, it provides an important service to the community by allowing patients, visitors, and hospital staff to use the mini stop to travel to and from the hospital, reducing traffic congestion and parking problems. It is crucial to have a train station close to a shopping center and an industrial area such as Kashar for both financial and environmental reasons. It enables workers and customers to get around easily and effectively, promotes economic growth, and lessens traffic congestion and pollution. Additionally, fewer vehicles on the road can aid in lowering carbon emissions and air pollution, which will benefit the environment and the general public's health.

3. DISCUSSION

The future of cities depends on integrating transportation methods and implementing infrastructure at a human scale. This strategy prioritizes pedestrian and cycling infrastructure and involves designing infrastructure that is secure, comfortable, and accessible for people of all ages and abilities. By lowering greenhouse gas emissions, tackling climate change, and promoting a healthier lifestyle, it also contributes to the sustainability of cities. This strategy has many advantages, including improved mobility and accessibility, a livable environment, and a sustainable future. Prioritizing people's needs and using a strategy that supports inclusivity, health, and sustainability are crucial as cities expand and change.

REFERENCES

[1] A.A. Rassafi, M. V. (2005). Sustainable transport indicators: Definition and integration. International Journal of Environmental Science and Technology, 2, 83-96.

[2] Administration, F. R. (2020). RAILS WITH TRAILS. U.S Department of Transportation.

[3] Eco-Project. (2021). in-depth Environmental Impact Assessment Study for the rehabilitation of the Durres-Tirana. https://hsh.com.al/.

[4] Ibem, E. O. (2009). Community-led infrastructure provision in low-income urban communities in developing countries: A study on Ohafia, Nigeria. Cities, 26(3), 125–132. https://doi.org/https://doi.org/10.1016/j.cities.2009.02.001

[5] Lee, E. S. A. (2010). Promoting sustainable transportation through the integration of cycling with public transit : lessons from Copenhagen and Munich for Singapore. http://hdl.handle.net/1721.1/62114

[6] Li, Y., Zhang, Y., Tiffany, L. A., Chen, R., Cai, M., & Liu, J. (2021). Synthesizing social and environmental sensing to monitor the impact of large-scale infrastructure development. Environmental Science & Policy, 124, 527–540. https://doi.org/https://doi.org/10.1016/j.envsci.2021.07.020

[7] Max-Neef, M., Hevia, A., & Hopenhayn, M. (1989). Human scale development: An option for the future. Development Dialogue, 1, 7–80.

[8] Monsere, C. M., McNeil, N., & Dill, J. (2012). Multiuser Perspectives on Separated, On-Street Bicycle Infrastructure. Transportation Research Record, 2314(1), 22–30. https://doi.org/10.3141/2314-04

[9] Nadimi, N., Sangdeh, A. K., & Kamkar, H. (2021). Developing sustainable transportation for university trips in low-income countries. Proceedings of the Institution of Civil Engineers - Engineering Sustainability, 174(4), 160–173. https://doi.org/10.1680/jensu.20.00058

[10] Sassen, S. (2004). Local Actors in Global Politics. Current Sociology, 52(4), 649–670. https://doi.org/10.1177/0011392104043495

[11] Brömmelstroet, M., & Bertolini, L. (2010). Integrating land use and transport knowledge in strategy-making. Transportation, 37(1), 85–104. https://doi.org/10.1007/s11116-009-9221-0

[12] Sassen, S. (2004). Local Actors in Global Politics. Current Sociology, 52(4), 649–670. https://doi.org/10.1177/0011392104043495

Reflections on the Environmental Control Studio: Sustainability in architectural education, encompassing both the building and urban scale

Nerina Bajçi[1] *, Ina Dervishi[1], Sokol Dervishi[1]

[1]*Department of Architecture, Faculty of Architecture and Engineering, EPOKA University, Autostrada Tiranë-Rinas, km. 12, 1032, Tirana, Albania*
** Corresponding author: nbaci@epoka.edu.al;*

Abstract

In recent years, there have been new approaches to teaching renewable energy to meet the growing demand for sustainable energy systems. Unlike traditional architectural education, which does not cover renewable energy topics in its curriculum, renewable energy education is now recognized as a distinct field within architecture. Due to the complex and dynamic nature of the environment, a broader perspective with cross-disciplinary knowledge and skills is necessary. However, academic challenges still hinder sustainable architectural education development, such as unclear definitions and a shortage of experts in this area.

This paper focuses on architectural education's structure and environmental design's importance. The paper describes the experiences of the Environmental Control Studio in the Architecture Department at Epoka University and evaluates the outcomes of the educational process. The objective is to examine the relationship between the building and its environment, both inside and outside, through the design ideas created in the studio. The paper illustrates the main ideas by presenting examples of student work from the Architecture Department. The paper also discusses the development of "environmental consciousness" and establishing a dialogue between different scales of the environment in student work.

Keywords: *architectural education, building and urban physics, simulation-assisted design process, interdisciplinary, sustainability.*

1. INTRODUCTION

Sustainability is increasingly becoming a critical consideration in architecture. Incorporating passive systems into the architectural design can result in dynamic, stimulating interior spaces supporting human health and activities while reducing energy consumption [1-6]. However, it can obstruct views, create discomfort, and lead to excessive energy use if not done correctly [7-15]. Throughout the history of architecture, buildings have relied on passive systems such as natural ventilation, traditional materials, and daylight until advancements in technology, such as air conditioning, fluorescent lighting, steel frames, and elevators, made it possible to construct taller and deeper buildings more economically [16-26].

The main objectives of architectural education are to train skilled, innovative, and ethical professionals who can make meaningful contributions to society's social, economic, and cultural advancement, both domestically and globally. Architecture education is a multidisciplinary field encompassing humanities, social and physical sciences, technology, and creative arts. The Environmental Control Studio is an essential course in the architectural curriculum aimed at developing the capacity of architecture students to design energy-efficient and sustainable buildings. The proposed structure of the studio is a move in this direction, aiming

to raise awareness of sustainability, building physics, and energy simulation to support the continued growth of these subjects within the architectural community [27-31].

The primary aims of the studio are as follows:

i. Equip students studying the built environment with a solid understanding of building physics and energy simulation fundamentals.

ii. Encourage and stimulate the integration of these subjects into the design studio.

iii. Establish a network of critical architectural and engineering institutions for future collaborations and discussions.

iv. Identify areas for improvement and opportunities to enhance architectural education to produce future professionals capable of delivering sustainable and energy-efficient buildings.

This paper employs a research approach that focuses on investigating the role of the Environmental Control Studio in architectural education and design processes. The Environmental Control Studio is a medium that leverages computational tools to support all stages of designing and evaluating energy-efficient buildings, from the urban to the building scale. It combines procedural simulation and knowledge-based heuristic techniques to create an integrated system that facilitates developing and accessing solar-powered, environmentally friendly, and low-energy buildings.

2. MATERIALS AND METHODS

2.1. Approach

Epoka University's Architecture Department has included a design studio in its curriculum for third-year students, the Environmental Control Studio, to expose students to scientific approaches to environmental thinking. Environmental thinking encompasses technical and artistic processes, and this is the first-time students have been exposed to environmental issues in a technical capacity during their studies.

The course is divided into multiple phases. In the first phase, students are required to immerse themselves in the urban environment and analyze its physics by measuring urban morphology indicators: building coverage ratio, floor space index, façade-to-site ratio, façade to building coverage ratio, façade to volume ratio, volume-area ratio, average building height, open space ratio and the sky view factor. After estimating the above-mentioned factors, they are introduced to simulation tools. Using a Revit plug-in, Insight, they are asked to measure the irradiance obtained in the building facades; thus, they can form reasoning on the connection between urban geometry and irradiance. They are further encouraged to think and test possible strategies via simulations that could improve the obtained results. The case studied is the master plan of The Northern Boulevard of Tirana, emphasizing the impact a simulation-assisted performance-based design process can have on the expected performance of future neighbourhoods.

In the second phase of the studio course, which spans four weeks, the students shift their focus towards the building scale. They attend scientific lectures on different topics, such as daylight and artificial light, energy-related performance and diagnostics, acoustics, universal design, fire protection, and HVAC systems. Additionally, in groups of four, they start analysing and optimizing daylight in a school building previously designed by them. After estimating the daylight obtained in 4 main spaces of the school (classroom, laboratory, cafeteria, library) via simulation software (Velux) they performed a thorough research on possible strategies that could help optimise the obtained daylight without compromising the view. They are provided with guiding literature on recommended lighting levels for school premises during the optimization process. Firstly, the task aims to sensitise them to the significance of architects' environmental and sustainability concerns and their impact on the design process, achieved by analyzing architecture and urban design. Secondly, it exposes them to various environmental issues and allows them to describe their approach to design.

2.1.1. Remarks on the project submission

Despite the varying perspectives and priorities of the student teams regarding environmental control and sustainability in the design process, they encountered similar research questions, leading to a wide range of optimization approaches that demonstrated consistent diversity across the class. Their experiences during lectures provided the foundation for their strategic development, but they faced challenges in integrating the various spatial scales and topics into their final proposals.

Through the course, students were compelled to reflect on and articulate their experiences, reinforcing their unconscious learning. The reports and presentations revealed that students were cognizant of their challenges and expressed them with clarity. The subsequent sections of the paper will summarize the issues explored.

2.2. Case study 01

The Tirana master plan is a new proposal to connect the Artificial Lake to the Paskuqan lake, running through the city centre. The old settlement in the area is disorganized and underdeveloped, with organic streets and no central axis connecting to the city's north side *(Figure 1)*. This proposal treats the existing urban fabric as a blank canvas and presents an opportunity for development. It includes a main boulevard divided into open public squares and green spaces, flanked by mixed-use open and closed blocks that will serve as a new institutional and commercial hub in the city.

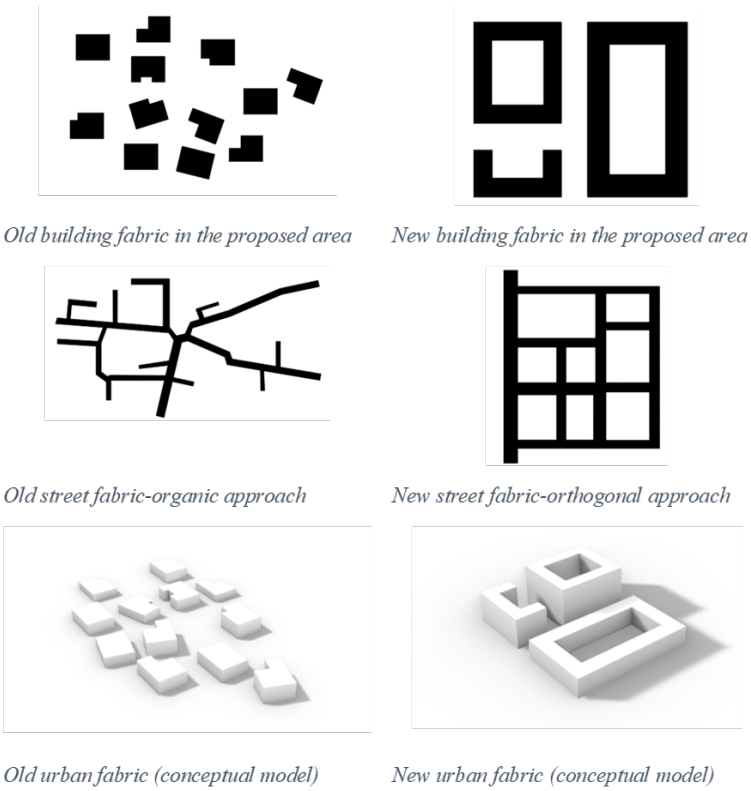


Figure 1. The existing and proposed morphologies of Tirana Northern Boulevard Masterplan

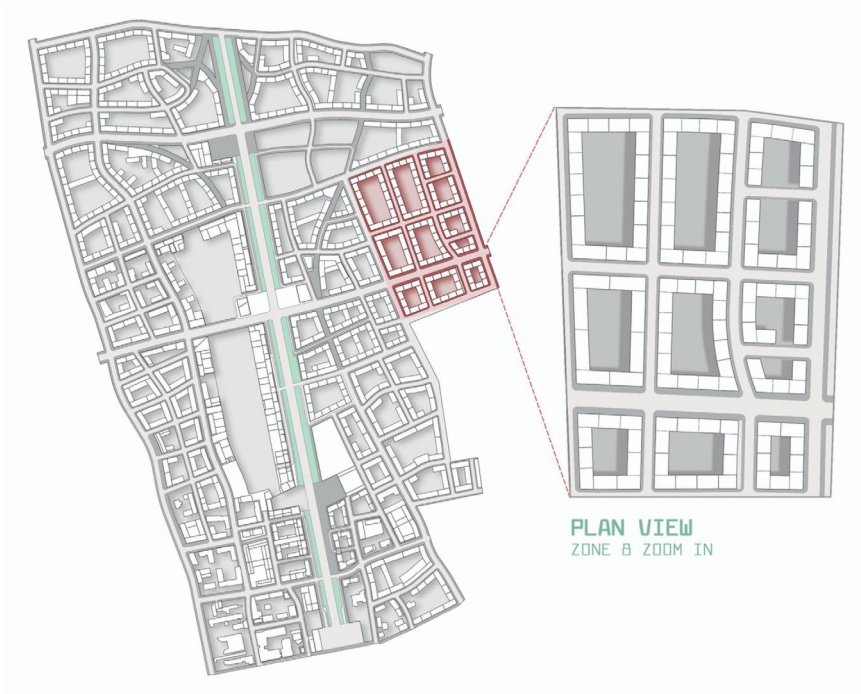


Figure 2. The studied zone of the Tirana Northern Boulevard Masterplan

This research aims to perform a thorough solar analysis of the masterplan to provide insight into its future performance and identify possible strategies to improve its performance. The first phase of the research process comprises a thorough urban analysis of the proposed masterplan. Urban indicators such as built and unbuilt area fractions, courtyard aspect ratio, and sky view factor are studied. The second phase uses the Insight plugin for Revit to conduct a solar analysis of the site during four critical days of the year: the spring equinox, summer solstice, fall equinox, and winter solstice *(Figure 3)*. This analysis generates sufficient data to compare different blocks further and provide an understanding of the irradiance levels in facades belonging to subtypes of courtyard block morphologies.

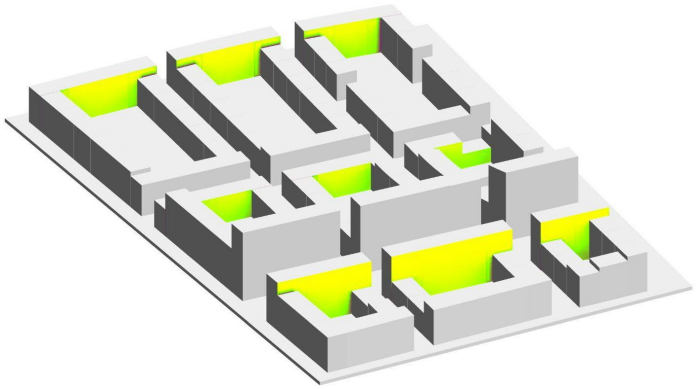


Figure 3. The irradiance of south-oriented inner facades during summer solstice before optimisation

After identifying the problematic facades, strategies are proposed for specific blocks to improve the situation. Floors are redistributed within the designed blocks to provide shade or more sunlight to inner/outer facades *(Figure 4)*. The strategies employed once more emphasise the importance of integrating simulation tools in the urban design process to obtain sustainable, better-designed neighborhoods.

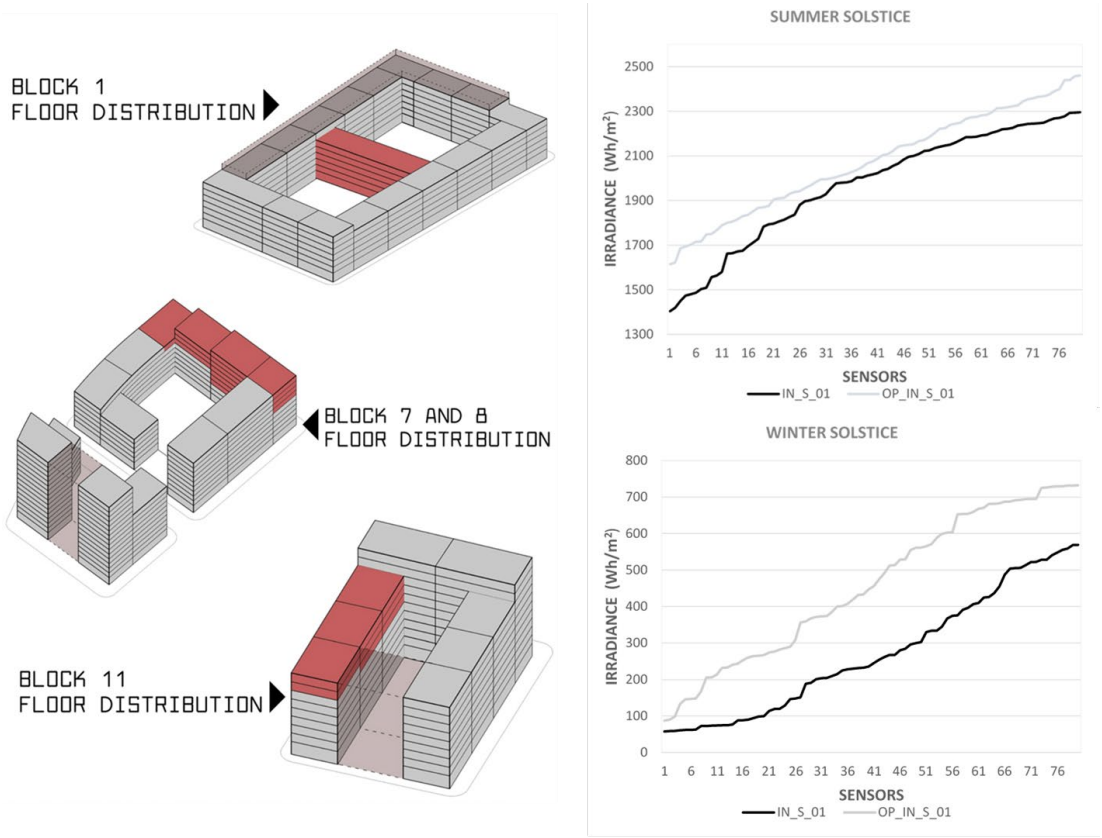


Figure 4. The performed optimizations (left) and a comparison of Irradiance [Wh/m^2] of inner, south-oriented building facade of block 7 before and after optimization (right)

2.3. Case study 02

Daylighting is an essential aspect of school building design that can significantly impact the learning environment. It refers to using natural light from the sun to illuminate interior spaces. The benefits of daylighting in schools include improved academic performance, increased teacher and student productivity, reduced absenteeism, and energy savings. Research has shown that students exposed to natural light perform better on tests, have better attendance rates, and are less likely to experience health problems such as headaches and eyestrain. Daylighting also reduces the need for artificial lighting, leading to significant energy savings and decreased greenhouse gas emissions. Therefore, it is crucial to consider daylighting in the design of school buildings to create a healthy, sustainable, and productive learning environment [32-37].

Located in Durrës, a coastal city in the central-western part of Albania, the analysed school building faces a Mediterranean climate characterised by mild and wet winters and hot and dry summers. The average temperature in January, the coldest month, is around 10°C (50°F), while in August, the warmest month, it averages around 27°C (81°F). The annual precipitation is about 950 mm (37 inches) and occurs mainly in winter. Durres is also prone to occasional thunderstorms and hailstorms during the summer months. The city enjoys many sunny days throughout the year, making daylight control a crucial issue for the buildings designed for such a context.

The first step of the research is estimating the amount of obtained daylight in four key areas of the school: classrooms, laboratories, cafeteria, and the library via Velux, a simulation software. A comprehensive investigation into potential approaches that could enhance the captured daylight without sacrificing the view,

is conducted. Considering both the building orientation and the facade design, vertical louvers are selected as the optimization strategy for the west-oriented classrooms.

The use of vertical louvres on west-facing classrooms can have a significant impact on the internal environment and energy efficiency of the building. By reducing the amount of direct sunlight entering the room, the louvres can help to control heat gain and glare, which can otherwise cause discomfort and make it difficult for students to concentrate. Additionally, by reducing the amount of solar radiation absorbed by the building, the use of louvres can also help to lower the overall cooling load, thereby reducing energy consumption and associated costs. Properly designed and installed vertical louvres can thus improve the comfort, health, and well-being of students and teachers while also contributing to the sustainability and efficiency of the school building [38-39].

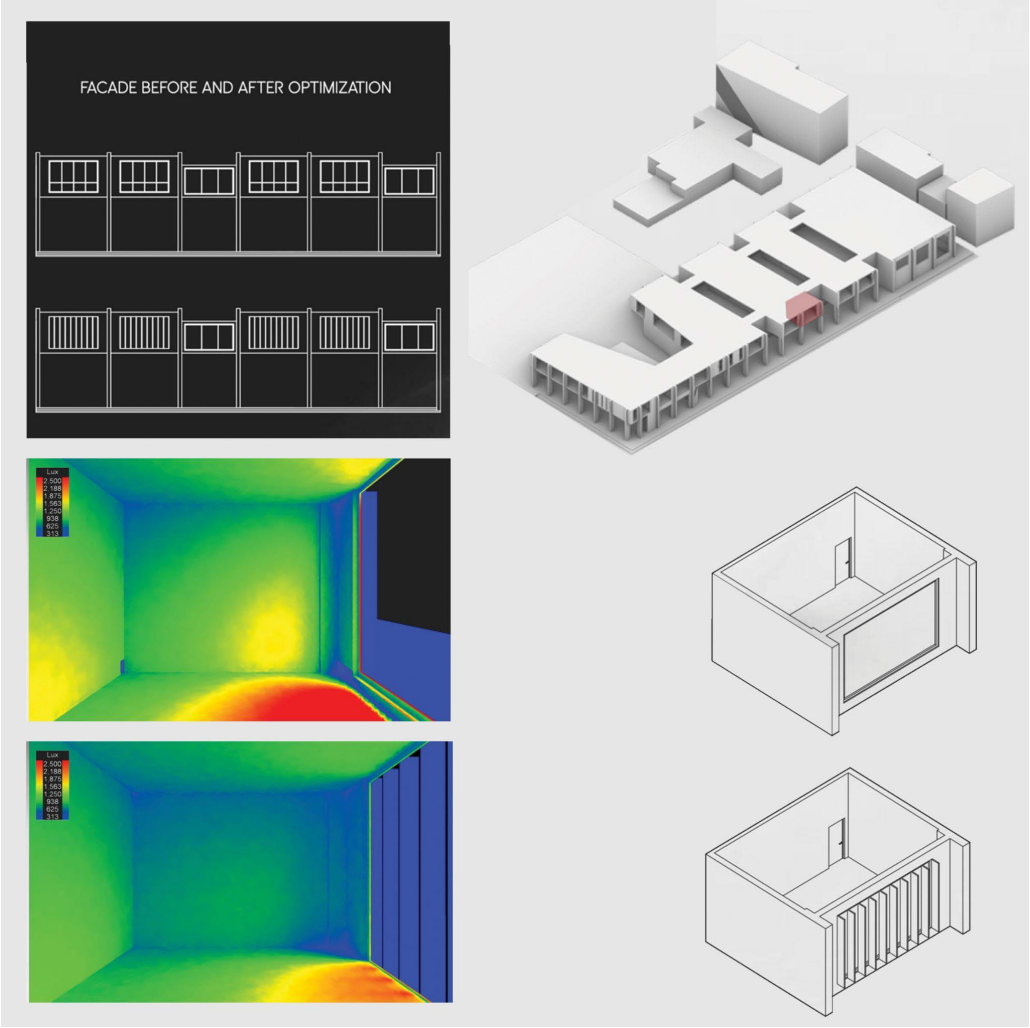


Figure 5. School building West facade before and after optimization (top left), simulation results of a classroom before and after optimization (bottom left), 3D model of the analyzed school building before and after optimization (top right), 3D model of the analyzed classroom before and after optimization (bottom right),

As clearly shown by the images extracted from the simulation software *(Figure 5)*, the proposed strategy somehow provides an equal distribution of light within the classroom while considering the adequate lux levels for the function housed.

3. CONCLUSION

Incorporating sustainable energy supply systems into architectural education is becoming increasingly crucial. Within architecture, renewable energy education is recognised as a distinct field. Due to the complex and multifaceted nature of the environment, a broader perspective and cross-disciplinary knowledge and skills are necessary. This paper discusses the obstacles hindering the development of sustainable architectural education, such as vague definitions and a need for more experts in the field. This paper focuses on the structure of architectural studies and the importance of environmental design. Specifically, it explores the experiences of the environmental control studio at Epoka University's Architecture Department and evaluates the educational outcomes. The paper examines how students develop "environmental consciousness" and engage with different scales of the environment by studying urban physics.

Performance-based urban and architectural design can pave the way for a sustainable built environment. Through the simulation-assisted design process of both a school building and a whole neighbourhood, the students were able to improve the expected performance and reduce the environmental impact.

Overall, the paper highlights the significance of environmental control studio in architectural education to enhance sustainable building design and identifies the challenges students encounter in integrating different spatial scales and topics into their final projects. The paper concludes by summarising some issues and providing recommendations for future research.

REFERENCES

[1] Padovan A, Del Col D. 2008. Measurements of solar radiation for renewable energy systems. In: Proceedings of ASME 2nd International Conference on Energy Sustainability, Jacksonville, Florida

[2] Braham, William W., and Daniel Willis. Architecture and Energy: Performance and Style. New York: Routledge, 2013.

[3] American Institute of Architects. 10 Steps to Environmental Sustainability in Architecture. Washington, DC: AIA, 2017.

[4] Royal Institute of British Architects. Sustainability in Practice: Supporting the Sustainable Design and Construction of Buildings. London: RIBA, 2017

[5] United States Green Building Council. Green Building and LEED Core Concepts Guide. Washington, DC: USGBC, 2015

[6] International Living Future Institute. The Living Building Challenge 3.0. Seattle: ILFI, 2014

[7] Dervishi, S., & Mahdavi, A. (2013). A simple model for the derivation of illuminance values from global solar radiation data. Building Simulation, 6(4), 379–383

[8] Mahdavi, A., & Dervishi, S. (2011). A comparison of luminous efficacy models based on data from Vienna, Austria. Building Simulation, 4(3), 183–188.

[9] Dervishi, S., & Mahdavi, A. (2013). A simple all-weather sky radiance model. In Proceedings of BS 2013: 13th Conference of the International Building Performance Simulation Association (pp. 916–921).

[10] Dervishi, S., & Mahdavi, A. (2012). Computing diffuse fraction of global horizontal solar radiation: A model comparison. Solar Energy, 86(6), 1796–1802.

[11] Orehounig, K., Dervishi, S., & Mahdavi, A. (2014). Computational derivation of irradiance on building surfaces: An empirically-based model comparison. Renewable Energy, 71, 185–192.

[12] Mahdavi, A., & Dervishi, S. (2010). Approaches to computing irradiance on building surfaces. Journal of Building Performance Simulation, 3(2), 129–134.

[13] Mahdavi, A., & Dervishi, S. (2011). Exploring the energy performance of simulation-powered lighting and shading systems controls in buildings. In Proceedings of Building Simulation 2011: 12th Conference of International Building Performance Simulation Association (pp. 772–778).

[14] Mahdavi, A., Schuss, M., Suter, G., Metzger, S., Camara, S., & Dervishi, S. (2009). Recent advances in simulation-powered building systems control. In IBPSA 2009 - International Building Performance Simulation Association 2009 (pp. 760–766).

[15] Dervishi, S., & Mahdavi, A. (2013). A simple all-weather sky radiance model. In Proceedings of BS 2013: 13th Conference of the International Building Performance Simulation Association (pp. 916–921).

[16] Dhanshetti, Hemlata C., and Arun B. Ingle. "Passive Design Strategies in Building Energy Efficiency: A Review." Journal of Green Building 16, no. 3 (2021): 31-56

[17] Al-Ansari, Tawfiq F., and Anwaar H. S. Al-Taie. "Assessment of Passive Design Strategies for Energy-Efficient Buildings in Hot Climates." Journal of Sustainable Development 14, no. 1 (2021): 1-17

[18] van der Velden, Jeroen, Jing Lu, and Wim Zeiler. "Assessment of Passive Cooling Strategies in an Energy-Efficient Office Building." International Journal of Low-Carbon Technologies 16, no. 1 (2021): 43-53

[19] Naderi, Nader, Abdullahi Ahmed Ali, and Sima Attari. "Passive Design Strategies for Low-Carbon Buildings in Hot and Humid Climates: A Review." Journal of Environmental Planning and Management 63, no. 4 (2020): 610-626

[20] Ali, Abdullahi Ahmed, Nader Naderi, and Sima Attari. "The Impact of Passive Design Strategies on Energy Consumption and Indoor Thermal Comfort in Hot and Arid Climates." Journal of Building Engineering 28 (2020): 101011

[21] Göçer, Ö., & Dervishi, S. (2015). The use of building performance simulation tools in undergraduate program course training. In 14th International Conference of IBPSA - Building Simulation 2015, BS 2015, Conference Proceedings (pp. 2781–2786). International Building Performance Simulation Association.

[22] Dervishi, S., & Baci, N. (2022). Early Design Evaluation of School Building Morphology on Energy Performance: Climatic Contexts of Southeast Europe. Energy Vol. 269, 15 April 2023, 126790

[23] Picari, V., & Dervishi, S. (2019). Analysis of urban heat Island phenomenon and mitigation strategies for Tirana, Albania. In Building Simulation Conference Proceedings (Vol. 6, pp. 3786–3793). International Building Performance Simulation Association.

[24] Dervishi, S., Lacaj, E., & Vathi, R. (2012). Urban heat islands (UHI) mitigation in densely urban city of Tirana, Albania: Materials, energy, comfort. International Journal of Business & Technology, 1(1), 48–57.

[25] Dervishi, S., Pashako, F., Dushaj, X., & Dervishi, I. O. (2022). Energy performance optimization of traditional housing in Mediterranean climate. Journal of Building Engineering, 45, 103423.

[26] Belba, R., & Dervishi, S. (2018). Thermal performance analysis of traditional housing in Albania (pp. 1485–1490). Syracuse University Libraries.

[27] Resuli, P., & Dervishi, S. (2015). Thermal performance of cultural heritage Italian housing in Albania. In Energy Procedia (Vol. 78, pp. 753–758). Elsevier Ltd.

[28] Dervishi, S., & Karamani, S. (2020). Exploring the energy performance of an existing industrial building. In E3S Web of Conferences (Vol. 181). EDP Sciences.

[29] Breçani, R., Belba, R., & Dervishi, S. (2019). Simoptimisationsted energy optimization of abandoned agricultural facilities: An adaptive reuse approach. In Building Simulation Conference Proceedings (Vol. 4, pp. 2554–2561). International Building Performance Simulation Association.

[30] Breçani, R., & Dervishi, S. (2019). Thermal and energy performance evaluation of underground bunkers: An adaptive reuse approach. Sustainable Cities and Society, 46.

[31] Bano, P., & Dervishi, S. (2021). The imthe pact of vertical vegetation on thermal performance of high-rise office building facades in Mediterranean climate. Energy and Buildings, 236.

[32] Heschong, L., & Wright, R. L. (2002). Daylighting impacts on human performance in school. Journal of the Illuminating Engineering Society, 31(2), 101-114

[33] Newsham, G. R., Brand, J. A., & Donnelly, C. L. (2000). Classroom ventilation and student performance. Building and Environment, 35(4), 301-308

[34] Višković, A., & Čović, B. (2018). Energy efficiency and daylighting in school buildings. Energies, 11(2), 251

[35] World Green Building Council. (2016). Health, wellbeing and productivity in schools: The impact of green buildings on students and teachers. Retrieved from https://www.worldgbc.org/sites/default/files/HWP%20in%20Schools%20Report%20WEB%20PDF.pdf

[36] Shady, M. M., & Kamel, M. R. (2015). Impact of shading devices on building energy consumption and thermal comfort in hot and humid climates. Energy and Buildings, 89, 173-183. https://doi.org/10.1016/j.enbuild.2014.11.040

[37] Kim, K. H., Lim, J. H., & Cho, J. Y. (2019). Evaluation of shading devices in classrooms for energy conservation and daylighting performance. Sustainability, 11(19), 5311. https://doi.org/10.3390/su11195311

[38] Lam, K. P., Wan, M. P., & Wan, K. W. (2019). A study on the effectiveness of external shading devices in reducing building energy consumption in subtropical regions. Applied Energy, 239, 342-355. https://doi.org/10.1016/j.apenergy.2019.01.200

[39] Illuminating Engineering Society. (2011). The Lighting Handbook: Tenth Edition. Illuminating Engineering Society.

Universality of Housing Design: The Case of Prague, Czech Republic

Ernest Shtepani[1], Anna Yunitsyna[2]*

[1]*Faculty of Architecture, Tirana Metropolitan University, Tirana, Albania*
[2]*Department of Architecture, Faculty of Architecture and Engineering, EPOKA University, Autostrada Tiranë-Rinas, km. 12, 1032, Tirana, Albania*
** Corresponding author: ayunitsyna@epoka.edu.al;*

Abstract

During the twentieth century, the dwelling typologies and the building layout did not change radically. The increasing quality of life is reflected in standards through the growth of the minimal sizes of dwelling and its rooms and through the allocation of the places for new gadgets and equipment. The changing of the households' structure; changing of activities; increase of the home working; and changing cultural and lifestyle patterns make evident the demands for a new approach towards the domestic space size and functionality, which leads to different design layout and new housing typologies. The need for multipurpose spaces and for the housing typology, which can be universal in use, is evident. The quality of space in dwelling design should be defined both by its ability to adapt basic living activities, and by its possibility to be universal in convenient use for different situations. This study focuses on the evaluation of the universality of dwelling, using as case studies housing complexes, which are built in the Czech Republic during the last 15 years. The universality of dwelling depends on the number of multifunctional rooms, while within each room the universality level is based on the number of accommodated activities. Room area, width, and the number of access points are set as the universality indicators. The analyzed cases demonstrate the high potential towards the universality of dwelling, which can be achieved just through different designs of the internal layout of the apartment without spending extra resources.

Keywords: *Universal housing, adaptable dwelling, Czech housing, universal space, flexible housing.*

1. INTRODUCTION

After changing the political system in 1989 from a Communism to a Democracy, the paradigm towards housing design and construction in the Czech Republic was also changed. The extensive public construction, theoretical works, standardisation, and development of the specific types of dwellings were replaced by the growing interest toward individual housing. The rising worldwide interest towards technologically and socially sustainable construction was mostly ignored. Housing policies also not adapted to the needs of these international trends [1].

Czech Housing Standard determines minimal space for eating, cooking, bathing, sleeping, social and familiar relations in accordance with the internal accesses to each space and public outdoor environment. Today, there is a drastic change in human expectations about the house. People distinguish it also as a space for relaxation, work, study, and spending time with friends and family. 24% of full- and part-time employed work at home with an average amount of 3.2 hours per day [2]. All of these activities are still unlisted in building regulations. This understanding of dwelling process does not leave space for different

interpretations and innovation. As a possible prerequisite for change, in Swedish dwelling standard 'a space for homework' is mentioned and for the small dwellings it is allowed to overlap functions in one room, such as using the same table for eating and working [3].

There is an increasing demand in the dwellings with the lower room specification. [4]. The apartment design becomes more flexible, and users decide on the functionality of each room and on the set of activities that occur inside. Universal space can be found in housing units, which are used temporarily for the short time of living, such as hostels, students, and housing for seasonable workers housing. The occupants are supposed to stay there during short time, the dwelling must be affordable, and therefore users can experience less comfort. The needs of each single occupant can be different, so the space should be neutral. The universality of a whole house is directly related to the universality of each of its habitable rooms. Universal space is defined by Mies van der Rohe as a large room without interior divisions, which can be used in a variety of ways and fit any activity [5]. However, the size of the dwelling is limited and its spaces are permanently shaped by the walls. Therefore, the universality evaluation is based on the spatial indicators. The analysis starts from the assumption that the set of human needs, 'living activities', such as sleeping, eating, working, bathing, cooking, and getting together [6] is the same for all people. Lynch defined 'generalised adjustability' as the ability of the structure to be adequately suitable for the majority of users and the presence of extra space is one of the main criteria for achieving flexibility [7]. Manum [8] introduces the generality of dwelling, which is based on the possibility to host living activities without any physical changes in its layout [8]. Universal dwelling does not need significant modification or adaptation of structure through the lifecycle of occupants [9]. In the polyvalent dwelling, the spatial layout combined with the neutral by size and the shape rooms, which are suitable for all the specific problems that occur during the lifetime [10] and 'the degree of polyvalence" evaluated by the number of activities [11]. The position of spaces related to each other and related to the whole envelope of the dwelling unit is an important defining factor for the potentials for space use [12].

Universality of dwelling is a complex value, which depends on the physical qualities of spaces (the area and width of rooms) combining the dwelling and the way of their interconnection (number of access points to each room) [13]. In universal dwelling the living activities (working, sleeping, eating, cooking, and socializing) can be performed in every habitable room. The universality of the single room is based on the number of hosted functions.

2. METHODOLOGY

Universality criteria are tested on contemporary examples of Czech residential architecture. There are selected 50 examples of dwelling complexes built during last 15 years. Within the studied 4+kk apartments 12 are built in the regions of the Czech Republic and the rest in Prague. The selected apartments are one-floor flats. General information regarding each project is collected during the first stage of analysis. The habitable rooms are indicated using as the main criteria the sufficient daylight and the possibility to be separated by doors and door-like openings [8]. For the analysis, it is assumed that the rooms are not specialised. For each room, its area, width, and number of access points were evaluated. Apartment overall area was measured as well.

Evaluation of the universality of each apartment is done in several steps. The analysis starts from the evaluation of the universality of each room by three criteria and continues with the evaluation of the whole apartment. According to the Czech Housing standard "Obytné budovy ČSN 73 4301" the only space, which has potential to be universal, is an integrated living area or a combination of living, dining areas and kitchen. The minimum floor area for this space is 16 m2. Double and single bedrooms have areas consequently 12 and 8 m2, which makes such spaces specialized. Kitchen as habitable space is not mentioned. The universal room accommodates any of the four living actions.

3. ANALYSIS OF APARTMENT UNIVERSALITY

Universality analysis begins with an analysis of the trends of development of the area of the apartment and proceeds with the evaluation of universality of each room according to three criteria. The result of the research is the universality level comparison of each of four spaces and the resulting evaluation of the apartment.

3.1. Apartment area

Figure 1 shows the changes in the area of 4+kk apartment over time and to evaluate the balance between the habitable area of apartment and its total area. The total area of the apartment includes all indoor surface space, such as habitable rooms, circulation space, storages, toilets and bathrooms and excludes the outdoor spaces, such as balconies, terraces, and loggias.

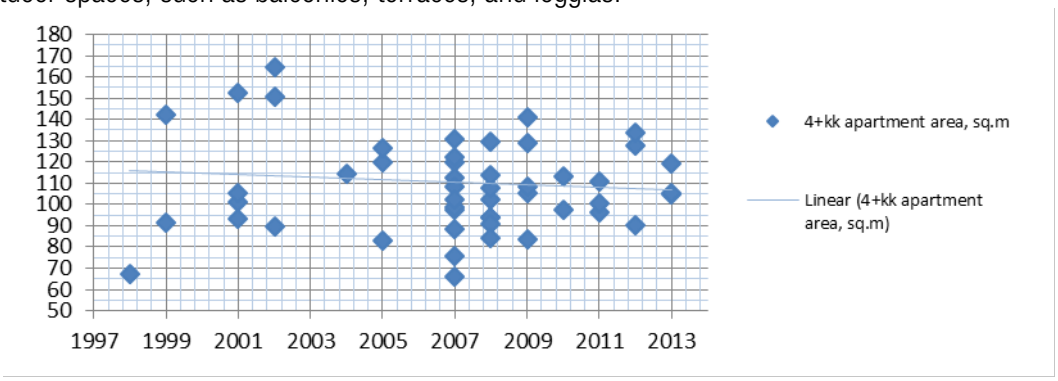


Figure 1. Area of the 4+kk apartment, m^2 and the year of construction

From the given distribution it may be concluded that the average area of 4+kk apartment is slightly decreasing within the last 15 years. During last 5 years the difference between the biggest and smallest apartments is smaller, meanwhile in early cases there is evident division on the big and small apartments. The average area of the apartment is 111 m2, and it ranges from 66.1 m2 to 217.5 m2.

The analysis proceeds with an evaluation of the efficiency of use of the apartment space (Figure 2). It is calculated as total area to habitable area (the sum of the four habitable rooms) ratio.

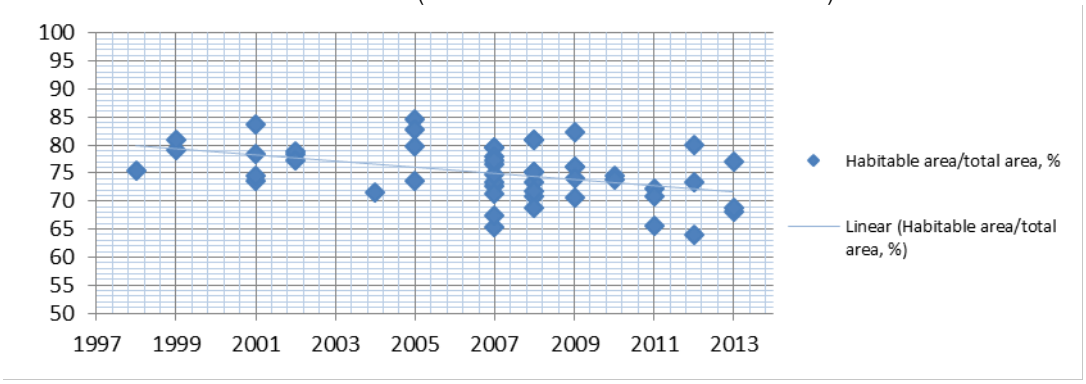


Figure 2. Habitable area to total apartment area ratio, %

The coefficient of use of the area is decreasing during last 15 years, which may be explained by the appearance in recent dwellings of the bigger service spaces, such as wardrobes, which can be projected as a separate space and extra bathrooms. The average coefficient of use is 75% and ranges from 66% to 85%. The overall decrease of the apartment size and of the coefficient of use allows for presupposing that the habitable area is decreasing with time, while the service area is growing. Within the average ratio of 75% and the knowledge of the minimal area of the universal room of 16.4 m2, it is possible to suggest the

minimal area of the universal apartment, which is 87.5 m2. Within the analysed case studies, only 6 have apartments are smaller, which means that the rest can be potentially universal.

3.2. Room area

The areas of the four habitable rooms are shown in Figure 3. There is a significant difference between the size of the biggest room, which is the living room, and the others. The areas of the three other rooms are similar, and the rooms become smaller with time.

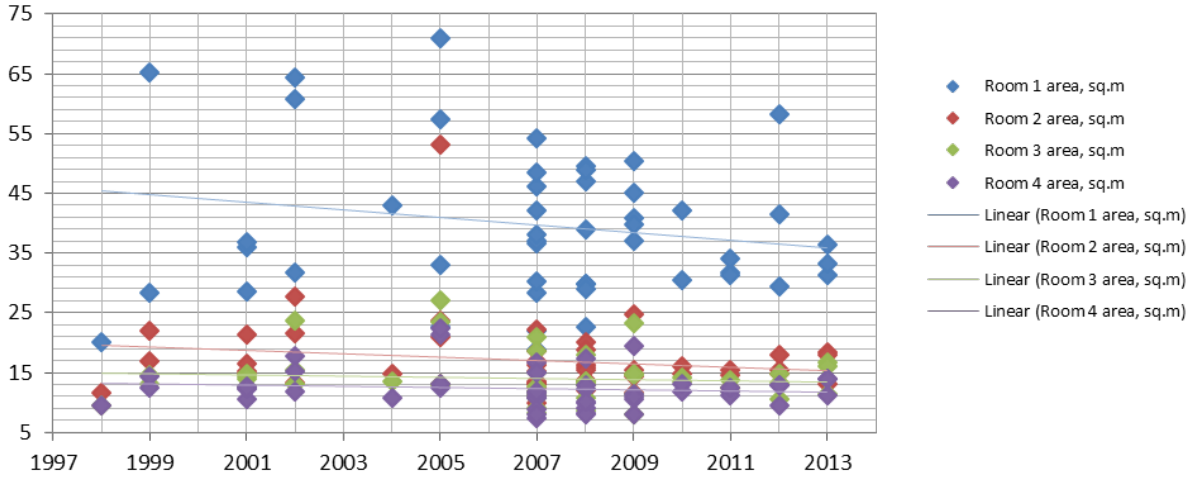


Figure 3. Room area, m^2

The range of room areas is shown in the Table 1:

Table 1. Minimal and maximal areas of the rooms, m^2

Room №	Max. area, m^2	Min. area, m^2
Room 1	78	18.9
Room 2	53.2	9.9
Room 3	23.5	8.3
Room 4	22.4	7.4

3.3. Room width

The changes in the width of the four habitable rooms are shown in Figure 4.Similar to the area, there is a significant difference between the width of the biggest room, and the others.

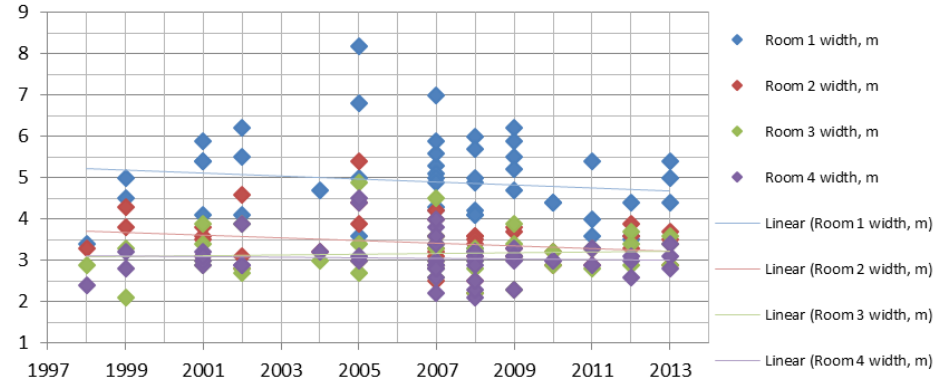


Figure 4. Room width, m

The width of the three smaller rooms is close one to another. The minimal width of the room is consequently corresponding to its size. For the Rooms 1, 2 and 4 it is decreasing, while the width of the Room 3 is growing up to the Room 2 level. The range of room widths is shown in the Table 2:

Table 2. Minimal and maximal width of the rooms, m

Room №	Max. width, m	Min. width, m
Room 1	8.2	3.3
Room 2	5.4	2.2
Room 3	4.9	2.1
Room 4	4.4	2.1

3.4. Room access

Figure 5 it shows the number of access points of the four rooms. The multiple numbers of access points is found majorly for the Room 1, meanwhile for the rest of the spaces it occurs in 4 cases.

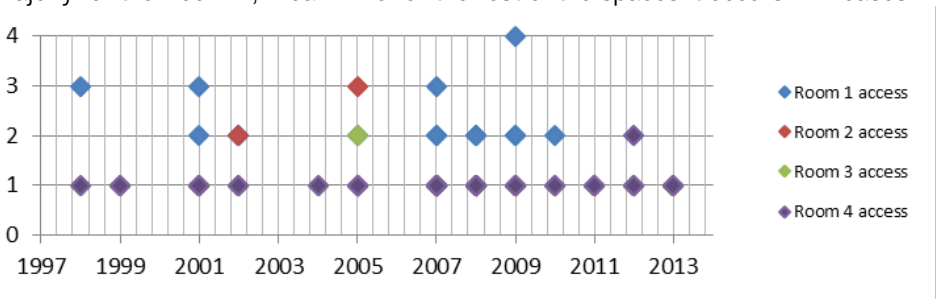


Figure 5. Room access

3.5. Universality of the room by three criteria

Table 3 presents the summary of the universal room criteria [13] including the area, width and the number of access points:

Table 3. Universality of the room criteria

Room area, m²	Room width, m	Access points	Universality degree
>16.4	>3.1	1	Universal
16.3-11.2	3.1-2.5	2	Accommodates 3 activities
11.2-8	2.5-2.2	3	Accommodates 2 activities
<8	<2.2	4	Specialized

In every apartment Room 1 can be considered universal by area. In 50% of the cases, Rooms 2, 3 and 4 can host 3 activities, which shows the low level of spatial specialization. Universality by width is higher than by size. Each of the analyzed Rooms 1 is universal, and the universality of Rooms 2, 3 and 4 is higher than 50%. The percentage of rooms with limited universality is smaller and only one of the analyzed spaces is specialized. In analyzed dwelling the width of the room in the majority of cases is satisfying the requirement of universality. By access rooms 2, 3 and 4 are mostly universal, and room 1 is universal only in half cases. Different levels of universality are established only for the Room 1.

Figure 6 demonstrates the result of the integral evaluation of the universality of each room by the criteria of area, width and access. For each room it was chosen the parameter with the lowest universality. From the chart it is visible the connection of the universality and the size of the room. With decreasing size, the overall universality is decreasing, and specialization is increasing. The prevailing type of universality has

the possibility of hosting 3 living activities out of 4. The number of completely specialized spaces is relatively small.

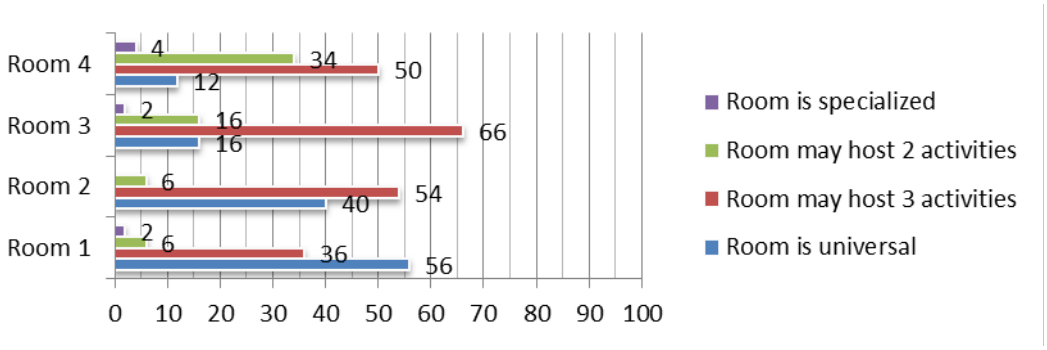


Figure 6. Universality of the room by three criteria, %

3.6. Universality of the apartment

The method of the evaluation of overall universality of each apartment is based on the previous calculating of the universality of each room. It is assumed that if each of the 4 rooms of apartment is universal, then the apartment is 100% universal. Each room has four levels of universality according to the number of accommodated living actions. Level 1 is the highest (universal) and 0.25 is the lowest (specialized). The universality of each of 4 rooms brings 25% to the universality of the whole apartment. According to the given method of estimation, the maximal universality can be 100% and the minimal – 25%. The final estimation of the universality of apartments and their development over time is presented in Figure 7.

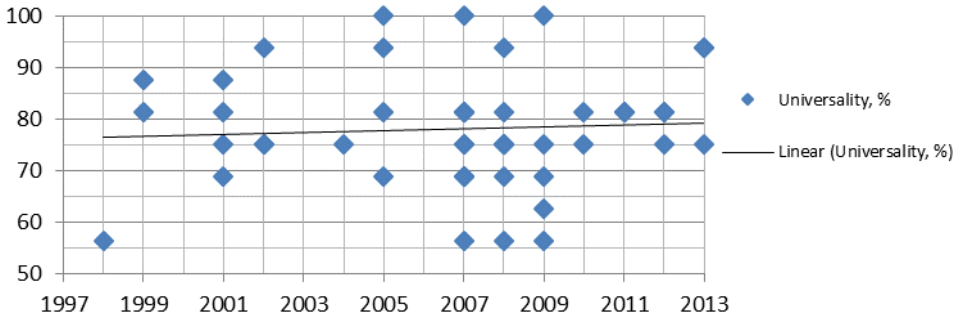


Figure 7. Universality of the apartment, %

According to the presented diagram, the universality of the analyzed dwellings varies from 56 to 100%. In three cases, which are residential complex Sacre Coeur, Dům na Kraji Sídliště and Rezidence Záběhlice in Prague, the level universality reaches 100%. Every habitable room of those apartments can be used for any of the four studied living activities. It can be concluded that minor growth of the level of universality exists within researched time frame. The average level of universality is 78%.

4. DISCUSSION

The overall area of the analyzed cases decreases slightly with time. It is larger than the minimal area of the universal apartment, which opens the possibility for every apartment to be universal. The coefficient of use is decreasing which shows the relative size reduction of the habitable rooms and increase of the service and transition areas. The overall universality of apartment is slightly increasing with time, which demonstrates the improvement of the spatial properties of apartment and each of its rooms with time.

The structure of the dwelling is not homogeneous. There is an obvious difference between the biggest room in the apartment and three others. Such difference is explained by the presumed function of this room, which is an integral living space – the combination of kitchen, living and dining areas. For each of the four habitable rooms, it is evident that the area with time. Rooms 2, 3 and 4 tend to have fewer area differences in the future. A similar situation occurs with a minimal width of room. Rooms 2-4 have almost no difference in width; while the width of room 1 is larger. The width of Rooms 1, 2 and 4 is decreasing with time. The difference in treating in project of room 1 and rooms 2-4 can be found in their characteristics by accessibility. Rooms 2-4 have only one point of access, meanwhile 2 and 3 points of accesses for the room 1. The overall number of universal spaces in decreases from Room 1 to 4. The prevailing partial universality allows the space to accommodate 3 out of 4 living actions. With decreasing the room size the specialization is growing, but in most of the cases rooms are partially universal and may host 2 activities.

88% of the apartments have a total area big enough to be potentially universal. The greater level of universality can be achieved by different layout design of the apartment without adding extra space. The spatial qualities of rooms 2-4 can be improved through decreasing of the Room 1 abundant size. Despite the fact that the Czech housing standard is based on the specialization of rooms; among the 50 cases there are three universal apartments. Universality may be achieved by establishing the minimum size of the room of 16.4 m2, which increases the average size of 4+kk apartment from 80.8 to 87.5 m2. Most of the analyzed dwellings have a larger area, which demonstrates a big potential towards the universality.

5. CONCLUSION

The analysis of 50 Czech residential complexes made evident the tendencies in changing of the apartment size as well as the area and width of the rooms. The analysis was carried out on the level of the apartment and on the level of the single habitable room. The object of analysis was the 4+kk type of apartment, within which the four habitable rooms were analyzed. European housing standards focus on the minimal dimensions of the rooms, which are highly specialized. The specificity of the Czech apartment layout allows to propose a guideline for the design of the universal dwelling. Establishment of the clear standard for the room requires to specify its measurements [14]. Most of the apartments have the area, which overpass the standard minimum, therefore the improvement of the design layout increases its universality. Introduction of the universality concept at the stage of the housing construction allows to minimize the future expenses occurring during the individualized layout adaptations. The paper aligns with the study of the minimal dimensions of the spaces of dwelling [15] but brings to the physical parameters of the room the criteria of its possible use. The study shows the possibility of solving the necessity to demolish the permanent walls inside of the apartment due to the changing needs of the inhabitant. There are several prerequisites towards it in the European legislation system. The unspecialized “habitable room” can be found already in few dwelling standards. Introduction of the universality recommendations in the standard, which address to improve the quality of living. The dwelling policies concentrate on the various aspects, such as sustainability, comfort, usability and adaptability of dwelling.

REFERENCES

[1] Kohout M., Tichy D. & Tittl F. (2015) Collective housing: a spatial typology, FA CVUT, Prague, Czech Republic

[2] ATUS, (2015) Bureau of Labor Statistics, US Department of Labor, Washington, USA.

[3] Swedish Board of Housing, Building and Planning, (2012) BFS 2011:26, General rules for buildings, Karlskrona, Sweden.

[4] Lobos D. & Donath D. (2010). The problem of space layout in architecture: a survey and reflections, *Arquiteturarevista,* 6(2): 136-161.

[5] Wilkinson C. & Eyre J. (2001) Universal space. Bridging Art and Science, WilkinsonEyre, London, UK.

[6] Leupen B. (2006) The Polyvalent Dwelling, in: *International Conference On Adaptable Building Structures*, Eindhoven, Netherlands.

[7] Lynch K. (1958) Environmental adaptability, *Journal of the American Institute of Planners,* 24:16-24.

[8] Manum B. (2005) Generality versus specificity, in: *5th International Space Syntax Symposium*, Delft, Netherlands.

[9] Randwick City Council, (2013), Development Control Plan, Randwick, Australia.

[10] Hertzberger H. (2001) Lessons for students in architecture, 010 Publishers: Rotterdam, Netherlands.

[11] Leupen B. (2006) Polyvalence, a concept for the sustainable dwelling, *Nordic journal of architectural research,* 19(3: 23-31.

[12] Hanson J. (2003) Decoding homes and houses, Cambridge University press: Cambridge, UK.

[13] Yunitsyna A. (2014) Universal Space in Dwelling – the Room for All Living Needs, in: *Proceedings of the 2nd ICAUD International Conference in Architecture and Urban Design*, Tirana, Albania.

[14] Chowdhury I. U. (1985) Housing and Space Standards: Human Needs and Regional Factors," in: *Regionalism in Architecture*, Singapore.

[15] Pedro B. (2010) How small can a house be?, in: *Sustainable development affordable to all. Low cost sustainable solutions*, Lisboa, Portugal.

[16] Takemoto N. (2004) Report and Recommendations: Loft Housing. CoolTown Studios, Washington, USA.

[17] Papež K., Kramlová J., Jelínek V., Kaňka J. & Kupilík V. (2004) Obytné budovy ČSN 73 4301, Česky normalizační institut: Prague, Czech Republic.

A comparative evaluation of post-earthquake RVS forms for determining building vulnerability and improving existing methods

Nurullah Bektaş[1]*, Janos Gergely[2], Orsolya Kegyes-Brassai[1]

[1] *Department of Structural Engineering and Geotechnics, Faculty of Architecture, Civil Engineering and Transport Sciences, Széchenyi István University, 9026, Győr, Hungary*
[2] *Department of Civil and Environmental Engineering, William States Lee College of Engineering, University of North Carolina at Charlotte, Charlotte, NC 28223, USA*
* *Corresponding author: nurullahbektas@hotmail.com;*

Abstract

In recent years, catastrophic earthquakes have caused devastating collapses all over the world, thus emphasizing the importance of taking the necessary precautionary measures to evaluate existing buildings prior and/or afterward to an impending earthquake. Because detailed assessment methods are not appropriate for assessing large building stock, Rapid Visual Screening (RVS) methods have been developed to assess large building inventory quickly. These methods are classified as pre-earthquake and post-earthquake building evaluation. Pre-earthquake RVS methods are used to determine expected performance of a building in an impending earthquake to take necessary precautions, whereas post-earthquake RVS methods are used to assess the level of damage afterward an earthquake. Existing pre-earthquake RVS methods, which are developed based on expert opinion, and data obtained from detailed building analysis and/or using data collected after an earthquake, are designed to determine the damage classes of structures prior to an impending earthquake. Additionally, even though all post-earthquake RVS methods were created to determine the degree of damage to a building after an earthquake, they differ in many ways, including risk assessment, usability classification, and in terms of data collection depth. Therefore, this study provides a comparative evaluation of two reinforced concrete and two unreinforced masonry structures with post-earthquake RVS methods (EMS-98, ATC-20, and AeDES) in order to elaborate on the similarities and differences between these methods. The importance of data collection forms of post-earthquake RVS methods in terms of the pre-earthquake RVS method development or enhancement for classifying building vulnerability, energy, and resource waste reduction has been discussed.

Keywords: *Earthquakes; Building Vulnerability; Rapid Visual Screening; Damage Grade; Risk Reduction.*

1. INTRODUCTION

The great damage to property in rural and urban areas as a result of earthquakes in recent years has shown that the existing building stock in many countries is vulnerable to earthquakes. Implementation of seismic vulnerability assessment methods to a building allows the determination of the vulnerability level and forecast the damage that may occur in an impending severe earthquake. Therefore, suitable vulnerability assessment methods are required to be performed for examining existing buildings. Consequently, in order to increase community resilience, pre-earthquake building assessment enables mitigation actions to be taken based on assessment results. To examine buildings, detailed vulnerability assessment, preliminary vulnerability assessment and RVS methods are used. In the event of a disaster, immediate building

assessment using rapid assessment methods is of the utmost importance, even though detailed vulnerability assessment and preliminary vulnerability assessment methods are computationally more accurate, but generally not available for most of the built infrastructure worldwide. Therefore, RVS methods were developed to assess post-earthquake damage levels of buildings.

RVS methods are developed to evaluate large building stock before and after an earthquake. Each structural and non-structural component of the building is inspected using these techniques to determine the extent of damage that has already occurred or is likely to occur. The goal of pre- or post-earthquake evaluation is obviously different, that can be detected in the effort and the detailedness of the employed assessment.

Prior to an impending earthquake the main question is vulnerability to determine the areas with higher risk, so pre-earthquake RVS methods can be employed to assess the vulnerability of a structure. These techniques, which have been developed globally, include FEMA P-154 [1], FEMA P-155 [2], FEMA 310 [3] from the United States; IITK-GSDMA [4] from India; EMPI [5] and RBTE 2019 [6] from Turkey; RISK-UE Project [7] from Europe; NRCC [8] from Canada; OASP [9] from Greece; JBDPA [10] from Japan; NZSEE [11] from New Zealand, have been developed with the aim of considering local building characteristics and varying methodologies. These methods are constantly developed based on post-earthquake damage data for reasonable results.

However, the priority after a major seismic event is to determine the damage extent and whether the buildings are safe for use or not. So, classification of building damage level after an earthquake is important in terms of efficiency and cost-effectiveness. Therefore, post-earthquake RVS methods are employed to assess the damage sustained by buildings following an earthquake. Among the various post-earthquake screening forms utilized by different organizations, the most comprehensively developed methods are FEMA P-2055 [12] and ATC-20 [13] from the United States, GNDT [14,15] from Italy, EMS-98 [16] from Europe. These methods are widely employed to evaluate structures following a seismic event. Aside from determining the extent of the damage, certain techniques, such as GNDT [14,15] and ATC-20 [13], are used to classify structures based on their occupancy and associated risks. In addition to adding more detailed building information, the screener can note the need for a detailed assessment of the building in light of the structural assessment in the notes/comments section of an RVS form.

Post-earthquake RVS methods differ in terms of the extent of structural and/or non-structural damage, risk assessment, and usability classification. Because post-earthquake RVS methods differ in terms of form content, this study presents a case study application of various de facto post-earthquake RVS methods (EMS-98 [16], AeDES [17], and ATC-20 [13]). Two reinforced concrete buildings damaged in the 2023 Kahramanmaras, Turkey earthquake and two masonry buildings damaged in the 2019 Durrës, Albania earthquake are considered in this study. For all four buildings, dozens of pictures were available showing the location and extent of structural and non-structural damage, covering both the exterior and interior of these structures.

2. SITE SEISMICITY AND BUILDING CHARACTERISTICS

In this study, two buildings from two different building types—unreinforced masonry and reinforced concrete—that were damaged in earthquakes in 2019 and 2023 in Albania and Turkey, respectively, were taken into consideration. These structures were evaluated using post-quake RVS techniques (EMS-98, ATC-20, and AeDES). Below are explanations of the site seismicity and the building characteristics of the investigated buildings.

On 6th February 2023 an earthquake occurred in Nurdağı, Gaziantep province of Turkey with a moment magnitude of 7.8 based on USGS [18]. The hypocentre of the earthquake was 10 km beneath the surface. Following this earthquake, another earthquake with a 7.5 moment magnitude (according to USGS [18]) occurred in Ekinözü, Kahramanmaraş, Turkey. These earthquakes caused tremendous damage to

nearby regions of Turkey and Syria. In this study, two reinforced concrete buildings from Hatay, Turkey are considered to perform the EMS-98, AeDES, and ATC-20 RVS methods.

The considered buildings consist of 7 and 15 floors, respectively. The post-earthquake pictures of the reinforced concrete buildings considered in this study are shown in Figure 1. In Figure 1 (a) a residential building with a business place at the entrance floor, creating a soft story due to less infill walls and a higher floor height. This building has a non-parallel system in plan (Y-shape), which makes the plan irregular. Additionally, since the front (A), left (B) and right (D) sides of the building have no infill walls at the entrance and mezzanine floors, but the back (C) side of the building was constructed with infill walls, this is causing a torsional irregularity. In Figure 1 (b) a building under construction with a particularly higher story height at the entrance floor and the absence of infill walls creates in the building a soft/weak floor. The building has an out-of-plane setback at the first story, which is a vertical irregularity type. Additionally, the building has an irregular plan shape.

(a) (b)

Figure 1. Reinforced concrete buildings damaged during 2023 Kahramanmaraş, Turkey earthquake from Hatay, Turkey (Source: Tunç Deniz Uludağ)

In 2019 an earthquake occurred in Durrës, Albania with 6.4 moment magnitude. The hypocentre depth of the earthquake was 22 km deep. Residential buildings experienced extensive damage during this earthquake. In this study, 2 masonry buildings from Tirana, Albania damaged during this 2019 Albania earthquake are considered to perform post-earthquake RVS methods.

The considered masonry buildings are selected from the buildings damaged during the 2019 Albania earthquake in Tirana, Albania. These buildings with load-bearing unreinforced masonry walls and concrete floor slabs represent a dominant building type in the region. The buildings consist of 4 and 5 stories. Both buildings are regular in the plan; in addition, the business locations on the ground floor cause a soft story (vertical irregularity) in comparison to the above stories. The post-earthquake images of the masonry buildings considered in this study are presented in Figure 2.

(a) (b)

Figure 2. Masonry buildings damaged after 2019 Albania earthquake from Tirana, Albania (Source: Diana D. Herbert)

3. POST-EARTHQUAKE RAPID VISUAL SCREENING METHODS

This section briefly describes the EMS-98, ATC-20, and AeDES methods used to assess these unreinforced masonry and reinforced concrete buildings, affected by the earthquakes that struck Turkey in 2023 and Albania in 2019 respectively.

3.1 EMS-98 Scale

The European Macroseismic Scale (EMS-98) [16], published in 1998, defines six damage states, ranging from Grade 0 to Grade 5, to make post-earthquake building damage state classification as illustrated in Table 1. These damage grades are correlated to the physical damage quantity of both structural elements (columns, beams, etc.) and non-structural elements (infills, partitions, etc). Grade 0 and 1 damage states typically result in slight or no structural damages, while Grade 0 and 1 damage states typically result in slight or no non-structural damages.

Table 1. Structural and non-structural damage states based on EMS-98

		Structural Damage	Non-Structural Damage
Grade 0:	No damage	No	No
Grade 1:	Negligible to slight damage	No	Slight
Grade 2:	Moderate damage	Slight	Moderate
Grade 3:	Substantial to heavy damage	Moderate	Heavy
Grade 4:	Very heavy damage	Heavy	Very heavy
Grade 5:	Destruction	Very heavy	Very heavy

3.2 ATC-20 Method

The ATC-20 report, which was originally titled Procedures for Post-earthquake Safety Evaluation of Buildings, was first released by the Applied Technology Council (ATC) in 1989. In 2005, ATC-20 was revised. ATC-20 [13] post-earthquake building assessment consists of a three-tier process: Rapid Evaluation, Detailed Evaluation, and Engineering Evaluation. Rapid and Detailed Evaluation methods are post-earthquake RVS methods. The degree of detail required to evaluate building characteristics and the data gathered regarding building information are where these two forms main differences. In addition to categorizing building damage as Inspected (green placard), Restricted use (yellow placard), and Unsafe (red placard) as

explained in Table 2, ATC-20 also enables screeners to offer an estimate of the building damage as a percentage of its total area, and to recommend any potential follow-up evaluation by structural, geotechnical or other professionals.

In recent years, various levels of emergency response agencies in the United States have successfully transferred (some sections of) the ATC-20-2 form to mobile phones and tablets with GPS and internet capabilities using the Survey123 (ArcGIS) application [19]. This enables incident command not only to tailor the depth and breadth of the actual questionnaire used after a particular incident, but to also follow in real time the progress of first or second responders to a disaster area, which enables them to efficiently manage their resources, and to visualize assessment results in a dashboard.

Table 2. ATC-20 [13] based building safety classification

Damage description	ATC-20 tags
Buildings, which have minor cracks in plaster or lath, or no visual damage, are classified to be Inspected (Green placard). Although the structure may require repairs, no obvious hazards were discovered in the structural system. No significant reduction occurs in the initial seismic resistance of the building. Use and occupancy of the building are not restricted.	Inspected – Green
It's possible that the building's chimneys and parapets have partially or fully collapsed, the infill and partition walls have developed cracks, and there may also have been structural damage that can be repaired. There is a dangerous situation that necessitates restrictions on use and occupancy of the building. As stated on the placard, use and/or entry of the building is restricted.	Restricted Use – Yellow
The building may have partially or fully collapsed, or out of plumb, extensive cracks may have occurred on the walls, and failures in the structural system can be observed. Extreme structural, external, and/or other risks may make buildings more susceptible to damage from aftershocks or creep. Because of this, it is unsafe to occupy or enter the building, and anyone wishing to do so must first obtain a permit from the local engineering department.	Unsafe – Red

3.3 AeDES Method

In 1997, the AeDES methodology was developed by the joint collaboration of National Seismic Survey (SSN) and Gruppo Nazionale per la Difesa dai Terremoti (GNDT) in order to assess buildings based on structural and nonstructural properties. In addition to structural and non-structural building damage level (Null, Light, Medium-Severe and Very Heavy) evaluation, the AeDES methodology can also be used to identify risk evaluation (derived from structural, non-structural, external and geotechnical) and usability classification (6 classes from A - Usable to F – Unusable) of the buildings. The comparison of damage levels of EMS-98 and AeDES are illustrated in Table 3. The damage state classification of AeDES [17] is mainly based on EMS-98 [16]. The difference between AeDES and EMS-98 is in damage states for different components of buildings that are separately identified. Consequently, overall building damage level can be assigned. Furthermore, the screening form used by AeDES provides the opportunity to collect further structural and geometrical data and enables the structural evaluator to identify prompt interventions to mitigate certain hazards.

Table 3. Comparison of AeDES and EMS-98 damage states

EMS-98	Grade 0	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5
AeDES	Null	Light	Medium - Severe		Very Heavy	

4 RESULTS AND DISCUSSIONS

The damage that occurred in the buildings that were taken into account for this study are described in this section, along with the findings of the assessment performed using post-earthquake RVS methods.

The post RVS forms were applied for this study based on many photographs recorded in the post RVS evaluation of the buildings and offered by screeners on the site.

The reinforced concrete building RC (a), as shown in Figure 1 (a), has shown spalling of concrete in the shear wall beam connection, beam-column connection failure, and permanent tilting. It has been categorized as Grade 4: Very Heavy Damage, Unsafe (Red placard), and D4-D5: Very Heavy, respectively, based on the results of the EMS-98, ATC-20, and AeDES evaluations, as shown in Table 4.

The still-under-construction reinforced concrete building RC (b), shown in Figure 1 (b), has extensive damage to the infill walls in addition to hairline cracks surrounding a column connection. It is categorized as Grade 1: Negligible to Slight Damage by EMS-98, Restricted Use (Yellow placard due to falling hazard of infill walls in certain areas) by ATC-20, and Light by AeDES, as shown in Table 4.

Figure 2 (a) shows the unreinforced masonry building URM (a), which has cracks in the plaster of the floors and two partition walls above the entrance door. As shown in Table 4, it has been categorized as Grade 2: Moderate Damage, Inspected (Green placard), and D2-D3: Medium-Severe, respectively, based on the results of the EMS-98, ATC-20, and AeDES evaluations.

Finally, the unreinforced masonry building URM (b) shown in Figure 2 (a) has plaster cracks on the walls and floors. As shown in Table 4, it has been rated as Grade 1-2: Slight to Moderate Damage, Restricted Use (Yellow placard due to falling hazard), and D2-D3: Medium-Severe by EMS-98, ATC-20, and AeDES, respectively.

Table 4. Post-earthquake assessment results of the buildings

	RC (a)	RC (b)	URM (a)	URM (b)
EMS-98	Grade 4 Very heavy damage	Grade 1 Negligible to slight damage	Grade 2 Moderate damage	Grade 1-2 Slight to moderate damage
ATC-20	Unsafe (Red placard)	Restricted Use (Yellow placard)	Inspected (Green Placard)	Restricted Use (Yellow Placard)
AeDES	D4-D5 Very Heavy	D1 Light	D2-D3 Medium-Severe	D2-D3 Medium-Severe

Post-earthquake assessment of URM and RC buildings has been performed based on the damage state definition provided in two tables in EMS-98. However, ATC-20 and AeDES have specific forms to collect building screening data and assessment. By using EMS-98, only the damage level of the buildings as a whole is determined. On the other hand, if the ATC-20 is used, besides determining the overall building damage level, the level of many hazard types is set as Minor/None, Moderate or Severe. Furthermore, estimated overall building damage amount is also provided as a percentage. In the post-earthquake screening form of AeDES, the damage level of each vertical structure, floor, stair, roof, and infill and partition is determined separately. Additionally, the level of pre-existing damage is also considered. Unlike the ATC-20, the AeDES form allows dividing the risk into four parts structural, nonstructural, external and geotechnical, and classifies them as low, low with countermeasures and high. Also, while usability classification is divided into three classes in ATC-20, it is divided into 6 classes in AeDES.

In ATC-20, a building may be determined as unsafe (red placard) due to external risk, while in AeDES, since the risk is identified to be external in addition to the building usability classification in AeDES, the local government or relevant personal can access more detailed information about the building from the screening form, which is also enabled in the ATC-20 through recommendation to further evaluate the building.

While short-term countermeasures are not determined in ATC-20 and EMS-98, short-term countermeasures related to the structural and non-structural systems are determined in AeDES RVS form. As these suggestions might help locals in implementing actions to hinder further injuries it also raises the question of the appropriateness of these measures based on rapid assessment without further detailed evaluation.

Since soft computing algorithms based RVS method development requires post-earthquake building screening data and/or detailed vulnerability-based created data, it is important to have a post-earthquake RVS method, that includes all the necessary parameters. Therefore, it is recommended to increase data

collection capability of post-earthquake RVS methods. The collected data may later be used to enhance existing pre-earthquake RVS methods or develop new ones. The parameters that need to be considered for data collection can be derived from pre-earthquake RVS methods. Some of the widely considered parameters are pounding effect, vertical and plan irregularity, possible danger to surrounding buildings, construction year, maintenance, structure geocodes, etc.

5 CONCLUSION

In this study, three different post-earthquake screening methods (EMS-98, ATC-20, and AeDES) were applied to two reinforced concrete and two unreinforced masonry buildings. Reinforced concrete buildings were selected from the buildings damaged in the 2023 Kahramanmaraş, Turkey earthquake, while unreinforced masonry buildings were selected from the buildings damaged as a result of the 2019 Albania earthquake.

The post-earthquake RVS methods employed in this study differ in terms of collecting information about buildings and/or determining damage, risk, and usability. These differences can usually be explained by whether the necessary information is detailed or not. With recording more details, the time spent on one building might increase but also the usability of the recorded data will grow. Decisionmakers can have a clearer view of the affected building stock to determine the right countermeasures.

Not only helps to mitigate the effects of an earthquake, these data collected during the application of these post-earthquake RVS methods can also be used to improve the existing pre-earthquake RVS methods or the development of new methods, they gain importance in terms of further development. As a result, it has been experienced that the time required for the evaluation of each building increases, while the collection of detailed information about the buildings allows local authorities or relevant persons to have detailed information about the building.

REFERENCES

1. Federal Emergency Management Agency (FEMA). FEMA P-154: Rapid Visual Screening of Buildings for Potential Seismic Hazards: A Handbook; Applied Technological Council (ATC): Waschington, DC, USA, 2015.
2. Federal Emergency Management Agency (FEMA). FEMA P-155: Rapid Visual Screening of Buildings for Potential Seismic Hazards: Supporting Documentation; Applied Technological Council (ATC): Washington, DC, USA, 2015.
3. Federal Emergency Management Agency (FEMA). FEMA 310: Handbook for the Seismic Evaluation of Buildings—A Prestandard; Applied Technological Council (ATC): Washington, DC, USA, 1998.
4. Rai, D.C. IITK-GSDMA Guidelines for Seismic Evaluation and Strengthening of Existing Buildings; Indian Institute of Technology Kanpur: Kanpur, India, 2005, 1–120.
5. Ansal, A.; Özaydın, K.; Edinçliler, A.; Erdik, M.; Akarun, L.; Kabasakal, H.; Aydınoğlu, N.; Polat, Z.; Şengezer, B.; Sağlam, F.; et al. Earthquake Master Plan for Istanbul, Metropolital Municipality of Istanbul, Planning and Construction Directorate; Geotechnical and Earthquake Investigation Department: Istanbul, Turkey, 2003.
6. Ministry for Environment and Urban Planning. Principles for Identifying Risky Buildings; Ministry for Environment and Urban Planning: Ankara, Turkey, 2019.
7. Milutinovic, Z.V.; Trendafiloski, G.S. RISK-UE Project: An Advanced Approach to Earthquake Risk Scenarios with Applications to Different European Towns: WP4: Vulnerability of Current Buildings; European Commission: Brussels, Belgium, 2003.

8. National Research Council (NRC). Manual for Screening of Buildings for Seismic Investigation; National Research Council of Canada: Ottawa, ON, Canada, 1993; ISBN 0-660-15381-5.
9. OASP (Greek Earthquake Planning and Protection Organization). Provisions for Pre-Earthquake Vulnerability Assessment of Public Buildings (Part A); OASP (Greek Earthquake Planning and Protection Organization): Athens, Greece, 2000.
10. Japan Building Disaster Prevention Association (JBDPA). Standard for Evaluation of Seismic Capacity of Existing Reinforced Concrete Buildings; Japan Building Disaster Prevention Association (JBDPA): Tokyo, Japan, 1997.
11. New Zealand Society for Earthquake Engineering (NZSEE). The Seismic Assessment of Existing Buildings: Technical Guidelines for Engineering Assessments—Initial Seismic Assessment—Part B; New Zealand Society for Earthquake Engineering (NZSEE): Wellington, New Zealand, 2017.
12. Federal Emergency Management Agency (FEMA). FEMA P—2055: Post—Disaster Building Safety Evaluation Guidance—Report on the Current State of Practice, Including Recommendations Related to Structural and Nonstructural Safety and Habitability, 2019.
13. Applied Technology Council (ATC). ATC-20-1: Field Manual: Postearthquake Safety Evaluation of Buildings; Applied Technology Council (ATC): Redwood, CA, USA, 2005.
14. Gruppo Nazionale per la Difesa dai Terremoti (GNDT) Manuale Per Il Rilevamento Della Vulnerabilità Sismica Degli Edifici - Istruzione per la compilazione della scheda di 1° livello, CNR Gruppo Nazionale Difesa Terremoti: Terremoti, Roma, Italy, 1993.
15. Gruppo Nazionale per la Difesa dai Terremoti (GNDT) Manuale Per Il Rilevamento Della Vulnerabilità Sismica Degli Edifici - Istruzione per la compilazione della scheda di 2° livello, CNR Gruppo Nazionale Difesa Terremoti: Terremoti, Roma, Italy, 1993.
16. Grünthal, G. European Macroseismic Scale 1998 (EMS-98); European Seismological Commission: Luxembourg, 1998.
17. Baggio, C.; Bernardini, A.; Colozza, R.; Corazza, L.; Bella, M.D.; Pasquale, G.D.; Dolce, M.; Goretti, A.; Martinelli, A.; Orsini, G.; et al. *Field Manual for Post-Earthquake Damage and Safety Assessment and Short Term Countermeasures (AeDES)*; EUR 22868 EN - 2007; European Commission—Joint Research Centre—Institute for the Protection and Security of the Citizen, 2007; p. 100.
18. U.S. Geological Survey Available online: https://earthquake.usgs.gov/earthquakes/eventpage/us6000jllz/pager https://earthquake.usgs.gov/earthquakes/eventpage/us6000jlqa/pager.
19. ArcGIS Survey123.

Automation Procedures in Surveying Technologies for Accurate and Efficient Surface and Volume Computations

Marsed Leti[1], Paola Berdufi[1]*, Mikaela Çela[1]

[1]*Department of Civil Engineering, Faculty of Architecture and Engineering, EPOKA University, Autostrada Tiranë-Rinas, km. 12, 1032, Tirana, Albania*
** Corresponding author: pberdufi20@epoka.edu.al;*

Abstract

Surveying as a Civil Engineering discipline is utilized to determine the relative coordinates in three axes of points on the land surface by using appropriate instruments and techniques. Two main aspects in a construction process are reducing the economical expenses and time needed for the project to be conducted. Therefore, the terrain's volume calculation (cut and fill) is an important task that should be managed in a short period of time with highest possible precision. Numerous studies by many researchers have demonstrated improvements in accuracy of volume calculation and data computations using various mathematical techniques. This paper aims to present an innovative and automated way of proceeding with the design of the terrain, to support the visualization of contouring, and furthermore to calculate in an immediate and precise manner the cut and fill volumes. In order to accomplish this project, the environment of AutoCAD is used for the final automation of the design. The whole process takes into account the data gathered from in-site measurements, research on 2D and 3D tools and commands of AutoCAD, scripting and Python programming, utilizing a super spline method for interpolation. The source of data is imported from a database saved on MS Excel through a prepared Graphical User Interface. The output results produce accurate AutoCAD drawings, including the surface and 3D volume. This method is tested initially using made-up data then data gathered from the surveying process. The final outcome imply that this method can significantly enhance the computation of terrain contouring, 2D and 3D terrain visualizations.

Keywords: *Surveying, Total Station, AutoCAD Scripting, Python Programming, Surface and Volume Calculation.*

1. INTRODUCTION

Surveying is a branch of Civil Engineering which deals with making relatively large-scale, accurate measurements of the Earth's surface in order to determine the relative position of both natural and man-made landmarks. It is labelled relative position because all the measurements that surveyors conduct to find the altitude of a certain point in terrain, consider the sea level as a benchmark point. To simplify the process of surveying benchmarks [1], permanent marks established at a known elevation that are used as the basis for measuring the elevation of other topographical points, are placed around the target location. Furthermore, the gathered data are processed and used by surveyors to originate topographical maps (Contour maps) [1], a map illustrated with contour lines, which shows the steepness or smoothness of slopes.

As the process of surveying involves the iterations of several calculations that requires a lot of time and leads to many mistakes, errors and blunders. Hence, the need for a specific and efficient tool is essential for such computations. In this study it is presented a methodology of the automation procedure followed to conduct mass computations in the surveying field. Automation in the generation of complex coordinate systems not only saves time but also increases the accuracy of terrain digitalization and reduces the possibility of human errors. This project provides a demonstration of the implementation of Python and AutoCAD scripting in calculating and solving topographical demands. In particular, this study consists of the preparation of an efficient methodology for the automations of necessary drawings to compute the volume, prepare contour maps and generate 3D models.

The main scope is to facilitate the surveyors work and reduce the huge amount of time to achieve the required project details. The modelling stage will be conducted in AutoCAD software [2] for both 2D and 3D views of the site. AutoCAD is selected as a popular, user-friendly and accurate software for drawing purposes especially in 3D modelling. The automation will be based on the algorithms prepared for AutoCAD scripting [3]. AutoCAD scripting is known as a procedure on which the programmed file can be read from the AutoCAD macros and reproduce drawings at a high speed [4]. Each of the scripts will be prepared in the environments of Python Programming language [5]. Python version 3.7 is selected as a suitable and easy programming tool especially for civil engineering purposes [5].

The steps to be followed for the utilization of the requirements of this study are based on the initial data gathered from the survey equipment. This study is established on the usage of total station [6], which provides the minimal sufficient parameters to compute the 3D coordinates (x,y,z) of each point. These coordinates are derived from the distance and the angles provided from the total station. The database storage of the gathered data is structured in Microsoft Excel [7] and then recalled as a dataset in Python to be prepared for the AutoCAD scripting. The Script file contains a large amount of data and suitable commands-information which are recognized from AutoCAD software. The final output is the modelling of the 2D network surface, 3D terrain model and topographical contour map. Moreover, benefitting from AutoCAD pre-built algorithms it is possible to compute easily and precisely the surface area, mass volume and more surveying tasks.

2. MATERIALS AND METHODS

2.1. Surveying / Terrain measurements

As a subdiscipline of the wide range of civil engineering field, surveying assists in the process of evaluating a 3D landscape by using different tools and techniques. With the development of technology and computational power, advanced tools are part of the surveying process. Nowadays, surveyors benefit from the innovations of more advanced tools such as total station [6]. Total Station (TS) is an instrument placed and levelled in a point of known elevation (benchmark point) used to conduct accurate measurements in short duration of time. The total station instrument provides three main parameters which are the basics of computational methodology in surveying field.

These three parameters are the distance from the total station to the point of intersection where the mirror is secured, known in surveying field as the slope, the vertical angle (known as zenith angle) that the slope forms with the horizontal direction in a vertical plane, and the horizontal angle that the x-y- component of the slope forms with the horizontal direction with vertical plane. Using these outputs and geometrical formulas, the coordinates of each measured points are computed in 3D axis (x,y,z) which are later used to model a virtual simulation of the terrain, utilizing the commercial software of AutoCAD. Commercial software

like AutoCAD is selected as user-friendly tools which are developed with high level of accuracy. Benefiting from the strong background of CAD modelling, the mass volume can be achieved easily once it is set up correctly.

Table 1. List of source parameters used to develop the automation procedure

Inputs used in the automation process					Data collection from Total Station
Total Station *(m)*	Mirror Height *(m)*	Slope Distance *(m)*	Vertical Angle *(hexa)*	Horizontal Angle *(hexa)*	
1.65	2.10	52.508	86° 37’ 05”	353° 37’ 05”	
1.60	1.23	63.143	86° 49’ 25”	41° 53’ 25”	
1.60	1.23	27.733	83° 40’ 55”	105° 28’ 40”	
1.60	1.23	26.581	83° 25’ 50”	105° 28’ 40”	
1.65	1.23	28.55	86° 50’ 40”	76° 17’ 05”	

2.2. Designing in AutoCAD

The computer-aided drafting application AutoCAD is essential for such projects due to its efficiency and quality of the designs and generated databases for manufacturing. Its 2D and 3D working spaces and commands are used in order to complete the tasks. Utilizing straightforward and user-friendly procedures, every aspect can be edited effectively. Most used commands in this study are Purge, Spline, Line, Copy, Surfnetwork, Intersect, Union, Extrude, Planesurf, Slice, and Surfsculpt. The script file that automates the drawing process needs to be dragged and dropped into an AutoCAD workspace, so it is recognized automatically by the software macros for an automation procedure. However, using several times the same workspace may be subjected to remaining objects that can cause clashes with future scripts. Therefore, to avoid this phenomenon, "Purge" command is utilized to clean the workspace from any old and unnecessary drawings, groups, blocks or layers.

Addition to 2D modelling stage, an important phase of this study is to provide 3D models as well. To achieve this task, multiple 3D commands integrated in AutoCAD are utilized. The command "Surfnetwork" generates the surface between the curved splines and lines, and the command "Surfsculpt" is essential because it merges and trims a set of surfaces that completely enclosed a volume to build a 3D solid shape. The 3D solid, designed using the previous command, is measured to obtain the volume utilizing another well-known AutoCAD command “Measuregeom” which provides measurements for 3D/3-Axis, distance, radius, angle, area and volume. Once the list of commands needed to achieve the aim of this study is achieved, then it should be adopted in the scripting language which can be recognized by the AutoCAD software.

2.3. AutoCAD Scripting

The process of inputting manually all the points with their coordinates in three axes is time-consuming and prone to blunders, which would take longer time to identify and fix, making this a tedious process. The solution presented in this paper is based on AutoCAD scripting, a method of automating tasks in AutoCAD, without further knowledge in complicated programming languages [4]. AutoCAD scripting refers to the process of generating and running a series of commands and instructions within AutoCAD environment,

using a text file saved as script. Users can generate custom scripts in any text editor by setting the extension as ".scr", which can be loaded into AutoCAD and executed as a single command. Scripting allows users to automate repetitive tasks or sequences of commands, reducing errors and increasing productivity. Michael Best from the Arthur G. Russell Company in the journal article "AutoCAD Scripting from the Core (AutoCAD Core Console)" cites that "AutoCAD scripting is one of those 'out of the box' tools that has been in the software since the early 90's that became introduced to the public in 2013 and allows users to process drawings in a fraction of time and takes you to open a drawing and make the changes by hand" [8].

Using AutoCAD script to automate the process of terrain digitalization facilitates a long and tedious process to be conducted manually, generating splines, lines, surfaces and volumes. Using Python programming language to automate the AutoCAD scripting, leads to multiple lines of commands which are structured in a .scr file and recognized by CAD software. This script file can be used simply by drag and drop in the software's workspace.

2.4. Python coding

Python is a commonly used language to develop websites and software, analyze and visualize data and automate different processes. Python is a relatively easy language to be learned and used by beginners and non-professional programmers. Studies demonstrate that Python is a popular tool among civil engineers due to its simplicity, versatility and efficiency, which makes it suitable for a wide range of engineering applications such as Surveying [9].

In order to proceed with the code generation, the dataset structured and based in Microsoft Excel is imported through a built-in Python library known as Pandas [10], which is a fast, powerful, flexible, open-source data analysis and manipulation tool of the Python programming language. Pandas' library reads and saves this data as a "List", storing an ordered collection of elevation's points coordinates. This "List" is separated into smaller lists and used to automate the script-writing process. As a result, the data can be used easily throughout the code. The parameters grouped in these lists are unprocessed and cannot be included as raw data in the script file. Therefore, the geometrical formulas from the Surveying field are used to find the 3D coordinates of each point. The mathematical libraries which are already part of the Python language, are used to help in the generation of these coordinates that are grouped to be further utilized in the code.

Having the coordinates of each point, "Spline" command of AutoCAD is called by the Scripting file, to design curves by interpolating the point coordinates resulting in a "path". Further steps deal with the generation of surfaces based on calculated coordinates. This process is achieved by a list of commands and tools.

Surfaces were generated using the command "Surfnetwork", employing two by two the opposite splines, then grouped to design the final terrain surface. Each step was done inside separated Python "Functions" to structure the code in a more understandable way.

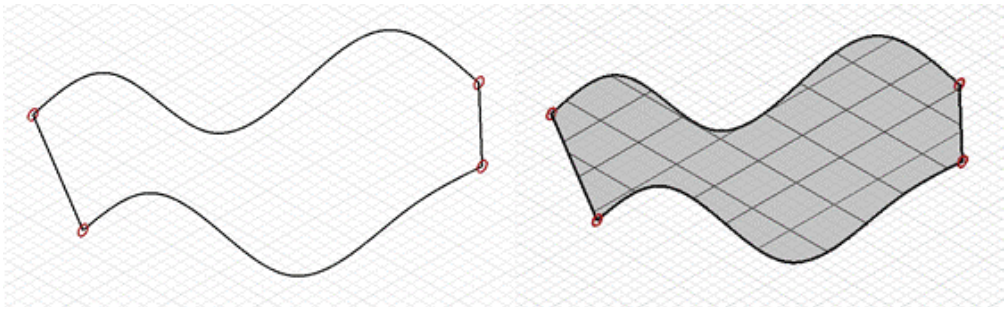


Figure 1. Surface created between two splines and lines

To generate the 3D visualizations of the terrain, it is followed a unique strategy adopted for AutoCAD environment. Initially, the corner coordinates are used by setting the z-parameter to zero. This leads to a 2D planar surface which can be easily extruded by "ext" command. The extruded shape it is used to generate the cut and fill volumes of the terrain. To achieve this task, the previous 3D surface is immersed in the extruded shape and then sliced. The slicing command provides the upper and bottom part which represent fill and cut volumes respectively.

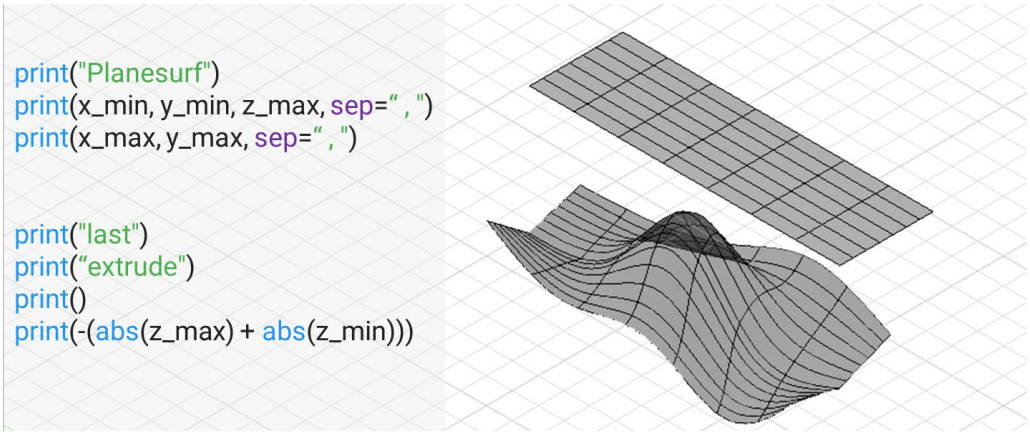


Figure 2. Python code and the generated design on AutoCAD

Figure 2 shows a part of the code written in Python which replicates all the commands needed to perform the steps mentioned above. By using the powerful SYS Module/library, each of the printouts can be written to a notepad file which at the same time provides the user real time observation for each individual process.

3. RESULTS AND DISCUSSION

The execution of Python code results in a well-structured AutoCAD script file which will be recognized by the CAD software. The procedure is simplified by dragging and dropping the script file into the AutoCAD workspace to draw all the coordinates, surfaces and volumes. Initially the coordinates are automatically inserted as data points and then connected by the powerful "spline" tool of CAD. The advanced procedures of 3D interpolation provided by the algorithm of 3D designing tools integrated in AutoCAD, make possible the generation of surfaces using the "network surface" command. Furthermore, the 3D modelling stage is strongly dependent on the previous calculated and drawn surface. The terrain's surface is immersed in a 3D extruded polygon which is generated by considering the corner coordinates of terrain with variation of depth

defined from the lowest and highest point of the site elevations. The developed “slice” tool is utilized to compute the fill and cut volumes which are defined as the volume above and below the surface respectively. The entire process transforms the huge amount of work into a precise computed 2D and 3D model in one of the commercial software's (AutoCAD) in less than 3 seconds.

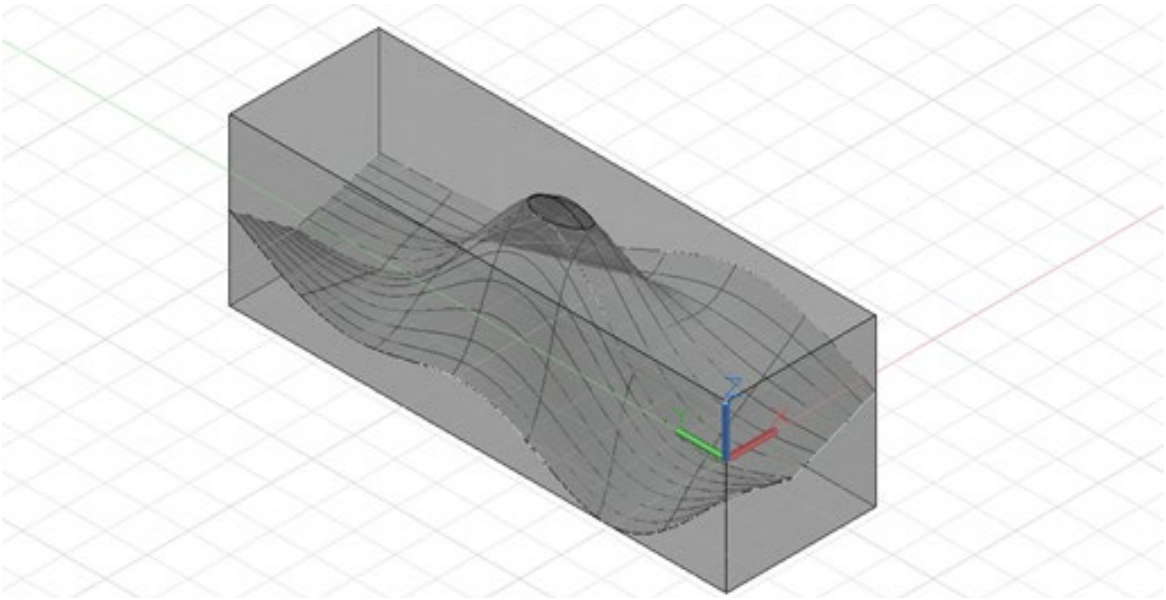


Figure 3. Final generated product from the script file automation

The generated 2D terrain from the automated procedure is composed of multiple merged surfaces, each defined from four coordinates. Figure 4 demonstrates the computed terrain from the AutoCAD software based on the integrated script. By considering the “Measuregeom” tool in 3D workspace of AutoCAD, the area can be measured effortlessly. At the same time, surveyors can derive the contour map and work with multiple tasks considering the facilities offered by AutoCAD. The generated surface, shown in the figure 4, helps surveyors to visualize the landscape where the tasks are to be executed.

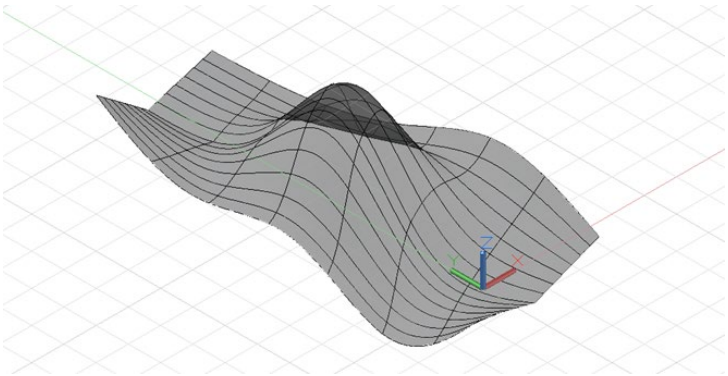


Figure 4. The generated terrain’s surface

Furthermore, this visualization assists civil engineers and surveyors to identify one of the best methods to level the terrain in the required quota, saving time, project budget and computational cost.

Engineers try to balance the amount of excavated soil to the amount of material needed to fill the terrain parts, which requires multiple design trials to measure the volumes. Thus, the precise volume measuring in cut and fill is part of the automation process using AutoCAD scripting and Python programming language. The upper part of the solid, as shown in figure 5 is the volume needed to be filled in order to

achieve the project quota, at the same time the bottom portion of the mass is the volume that can be excavated depending on the project targets.

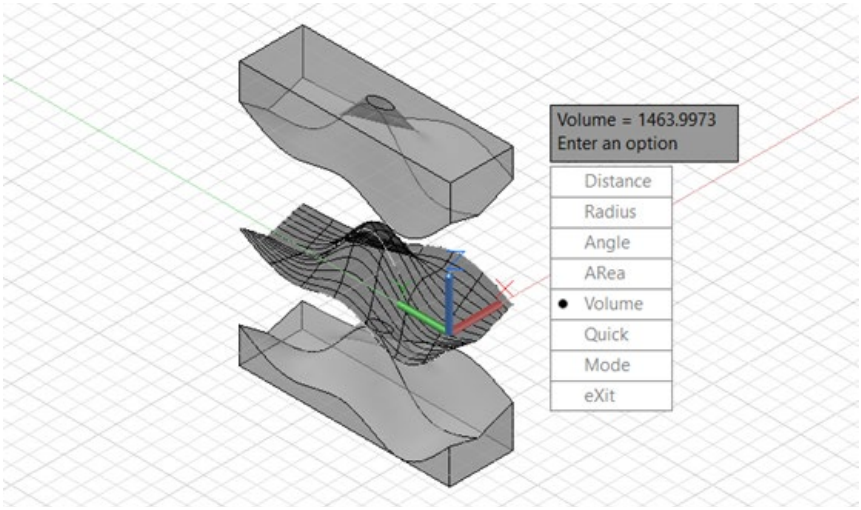


Figure 5. Cut and fill volume of the terrain

Comparisons with a manually designed terrain utilizing the same database under four weeks of work are made and the matching results are satisfactory, whereas the final output shows a high level of accuracy, fast and effortless computational modelling in few seconds.

4. CONCLUSION

The goal of this project was to develop methodology for automation procedures in Surveying field. The modelling stage is developed in the environment of AutoCAD software, well known for its accuracy drawings. The data automation relies on replication of CAD commands structured in a script file. To prepare the script, Python programming language is utilized, and a detailed methodology is presented step by step, for the adoption to AutoCAD macros. The final output generates effortlessly 2D and 3D digitalization using the data coordinates sourced from a database prepared while conducting site measurements. A case study is demonstrated for a four-week task period done manually using the same drawing software and tools. The results show that in comparison with conventional methods of data processing and visualizations in AutoCAD, the automated procedure shown in this paper provides more accurate drawings, less computational efforts and undoubtedly huge saving time.

REFERENCES

[1] T. Contributor, "Tech Target- Definition of Benchmark," November 2022. [Online]. Available: https://www.techtarget.com/searchcio/definition/benchmark, Accessed 2023].

[2] Autodesk, "Autodesk- AutoCAD," 2023. [Online]. Available: https://www.autodesk.com/products/autocad/overview?term=1YEAR&tab=subscription. [Accessed 2023].

[3] Autodesk, "AutoCAD-About Command Scripts," 2023. [Online]. Available: https://knowledge.autodesk.com/support/autocad-lt/learn-explore/caas/CloudHelp/cloudhelp/2019/ENU/AutoCAD-LT/files/GUID-95BB6824-0700-4019-9672-E6B502659E9E-htm.html. [Accessed 2023].

[4] X. n. CAD, "Scripting in AutoCAD," 30 September 2020. [Online]. Available: https://xlncad.com/scripting-in-autocad/. [Accessed 2023].

[5] J. Stopak, "Writing to a File with Python's print() Function," 22 January 2022. [Online]. Available: https://stackabuse.com/writing-to-a-file-with-pythons-print-function/. [Accessed 2023].

[6] J. L. &. Tool, "Johnson Level & Tool," 7 March 2023. [Online]. Available: https://www.johnsonlevel.com/News/TheodolitesAllAboutTheodo. [Accessed 2023].

[7] Microsoft, "Microsoft Excel," 24 April 2020. [Online]. Available: https://www.microsoft.com/en-us/microsoft-365/excel. [Accessed 2023].

[8] M. Best, "AutoCAD Scripting," AutoCAD Scripting from the Core (AutoCAD Core Console), p. 14, 2020.

[9] Qi Cao, Vicki H.M. Dale, Nathalie Tasler, Li Hong Idris Lim, "EXPERIENCES IN PYTHON PROGRAMMING LABORATORY FOR CIVIL ENGINEERING STUDENTS WITH ONLINE COLLABORATIVE PROGRAMMING PLATFORM," in 14th annual International Conference of Education, Research and Innovation, Spain, November 2021.

[10] ActiveState, "What Is Pandas In Python? Everything You Need To Know," 9 August 2022. [Online]. Available: https://www.activestate.com/resources/quick-reads/what-is-pandas-in-python-everything-you-need-to-know, [Accessed 2023].

Development of Low-Cost Single-Axis Shaking Table Based on Arduino Microcontroller

Marsed Leti[1], Dajana Colaj[1] *, Agjelos Gjana[1]

[1]*Department of Civil Engineering, Faculty of Architecture and Engineering, EPOKA University, Autostrada Tiranë-Rinas, km. 12, 1032, Tirana, Albania*
** Corresponding author: dcolaj20@epoka.edu.al;*

Abstract

Recent devastating earthquakes in Balkan as well as other seismic prone countries have exposed the insufficient seismic performance of both masonry and reinforced concrete building stock. Although is not possible to estimate the occurrence and magnitude of upcoming earthquake, using today's technology it is possible to minimize the loss of life and constructions during the seismic event. Therefore, the need to develop an appropriate seismic hazard assessment is essential for both researchers and engineers. With the improvements of technology, the development and usage of small-scale shaking table has attracted the attention of researchers throughout the world. These devices are widely used to simulate ground motions and determine the dynamic behaviour of structures in laboratory experiments. In this study it is presented a methodology on the low-cost, mass-production of small-scale, one-axial shaking table for educational purposes. The term "mass-production" stands for replication of various devices with maximum possible accuracy for parallel demonstrations during academic events to enrich the background of students in the area of earthquake engineering. The shaking table components are 2D and 3D designed in AutoCAD and prepared from plexiglass material in the laser cutting machine to provide satisfactory level of precision. The dynamic movements are produced by servo motor type micro SG90. The accelerations are measured using MPU-6050 sensor and data acquisitions are controlled using Arduino UNO microprocessor connected directly to computer. The final prototype is able to demonstrate resonance effects of single degree of freedom structures considering low frequency and short amplitude movements.

Keywords: *Shaking Table, Earthquake Engineering, Arduino, Servo Motor, Low Frequency.*

1. INTRODUCTION

As one of the most hazardous phenomena, earthquakes cause every year excessive loss of lives and materials around the world [1]. The seismicity of Balkan is classified as the highest in Europe which is located in the middle of Eurasian and African tectonic plates [2]. In particular, Albania is well known as an active seismic region under the continuous hit of earthquakes which makes our territory under considerable risk [2]. During the November 26, 2019, our country was hit by an earthquake of 6.4 magnitude of Righter Scale which caused 51 deaths, over 3000 injuries and massive economical loss. This emerges the need to conduct more research on the performance assessment of the current construction stock in Albania as well as enrich the background of senior students in the area of earthquake engineering.

Among the analytical studies, there exist various ways to simulate dynamic motions by shaking table which provides a critical approach to earthquake research and education [3, 4]. Shaking table is an adequate tool which is used widely for the simulations of earthquake motions thus can help civil engineers identify the weakness in the design and provide necessary suggestions for local or global retrofitting [5, 6]. The examination of the structural behavior under seismic actions by considering large scale shaking table requires high budged and maintenance professionalism [7, 8, 9]. However, the structural performance can be studied by utilizing adequate scaling techniques in small size models. At the same time, the usage of small-scale shaking tables for research purposes is supported by many authors [10, 11, 12, 13].

In this study, a development methodology for mass-production of low-cost, small-scale, one-axial shaking table is demonstrated. The development of the prototype is prepared using well-known and affordable electronic hardware controlled and programmed from the computer. The final outcome provides low-frequency, harmonic motions used to simulate the resonance effect of different single degree of freedom (SDOF) structures for academic purposes in structural dynamics courses. By simulating dynamic motions in the classroom, students can better understand the forces involved and the factors that influence the behavior of structures [14], hence enriching the background and inspiring the next generation of seismic engineers.

2. MATERIALS AND METHODS

2.1. Development of Shake Table

In this study it is presented a methodology for the mass-production of small-scale shaking table in low cost for academic purposes. The mass-production requires high level of accuracy between product replications which is difficult to be achieved handmade. With the development of technology and computational power, it is easier and cheaper to conduct more accurate products. The shake table was conceptualized to perform dynamic movements in one-axis. Each of the physical and mechanical components are designed in AutoCAD 2D and 3D [15].

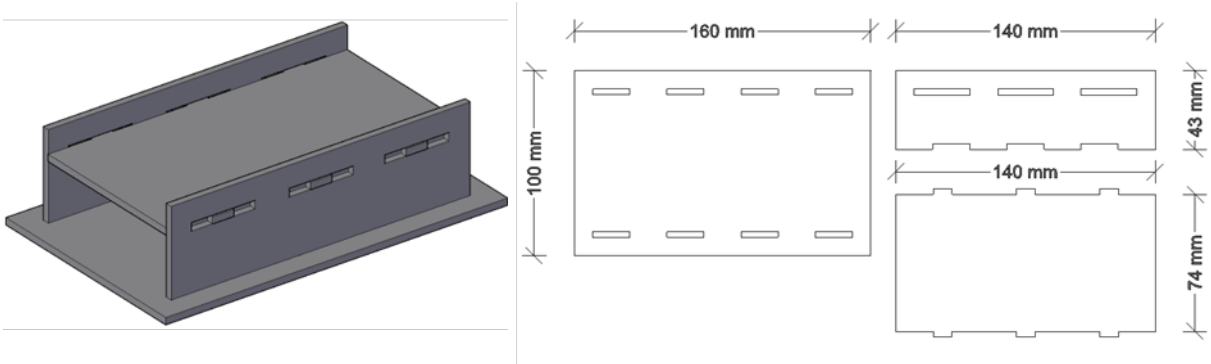
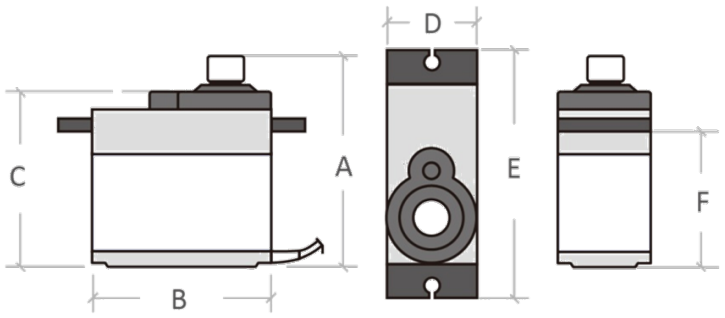


Figure 1. The 2D and 3D design of shake table components in AutoCAD software.

Furthermore, to achieve precise prototypes, these components are cut in the laser cutting machine [16]. The material used for the small-scale shake table are made of low-cost plexiglass which can be easily cut in the laser machine. The dimensions of the shake table are 140 mm by 74 mm in longitudinal and transverse directions respectively. Figure 1 shows the 2D and 3D design of the prototype in AutoCAD software.

The design of each component is accomplished in a way that allows the assembling of the final shake table prototype easily and perform low-frictional sliding. To generate electrodynamic actions, the entire process is structured in two main phases: generation of mechanical movements and data acquisition. To perform mechanical excitations, it is selected a servo motor SG90 [17]. SG90 servo is a tiny and lightweight motor which can perform 180 degrees rotations using different size arms. Its stall torque is about 1.8 kgf·cm and operating speed is around 0.1 seconds per 60 degrees under the normal operating voltage of 4.8-5 V. The dimensions and other parameters of the motor are listed in table 1.

Table 1. Servo motor SG90 specifications

Dimensions and Specifications		Technical Drawings
Torque (kgf·cm)	1.8	
Speed (sec/60deg)	0.09	
Weight (g)	9	
Voltage	4.8-5	
A (mm)	31	
B (mm)	22.2	
C (mm)	27.5	
D (mm)	11.8	
E (mm)	32.2	
F (mm)	16	

The servo motor is assembled in the shaking table prototype and adjusted to provide arm-rotations ± 35° which would give a maximum displacement of ± 9 mm.

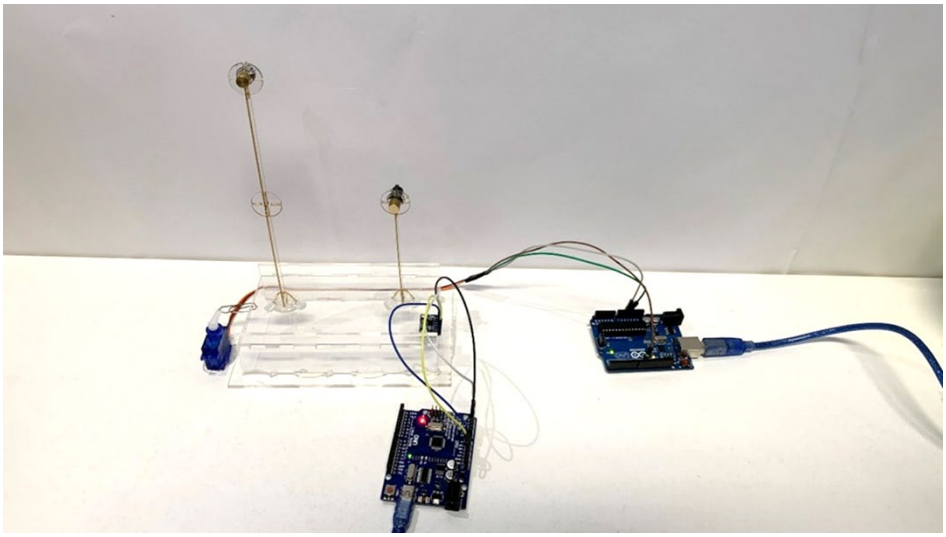


Figure 2. The developed shake table prototype.

For the motion control it is used an Arduino Uno composed of 8-bit ATMega328P Processor at a clock speed of 16 MHz with 32 KB flash memory [18]. The programming of the microcontroller is done directly from the computer using Arduino UNO ide [19]. The produced prototype is shown in figure 2.

2.2. Sensor and Data Acquisition

The low-cost shake table introduced in this study is developed from the self-designed and manufactured components using laser cutting machine. Even though the precision of the laser is quite better compared to handmade products, still there are possibilities to unwanted friction forces. These forces will be represented as noise when measured by the accelerometer sensors. To check the noise while simulating dynamic movements, a MPU6050 acceleration sensor [20]is used which is compatible with Arduino microcontroller. The MPU6050 can record accelerations in x-, y- and z-axis simultaneously. Therefore, the comparison of the noise in both orthogonal directions of the shake table can be easily achieved. The data acquisition is processed by Arduino Uno and presented in a graphical way using oscilloscope software [21]. This software provides the possibility to record the data in synchrony with real-time demonstrations during the simulations. The recorded values are then plotted and analyzed in detail.

2.3. Cost

One of the main targets of this study is to develop a low-cost shaking table for educational purposes. Each of the devices is selected according to the low-budget concept which at the same time ensures powerful computational speed to reach the objectives defined in the beginning of this study. The cost for each of the components used may vary by country, shipping fee etc. However, a general cost estimation of the overall shaking table provided in this study is calculated approximately €40. Based on the idea of supporting education by simulating dynamic motions and demonstrating structural behavior under seismic actions, the total cost for mass production of the shake table proposed can be easily funded by universities and other interested institutions.

2.4. Simulating harmonic motions

The Arduino UNO and servo communication is done based on the continuous pulse send from Arduino to the integrated chip of the motor. Changing the pulse and rest duration controls the rotation angle of the servo from the boundaries provided by manufacture, 0 to 180 degrees. The Arduino code uses the servo library [22] to simplify the entire process by providing rotations considering the starting and target angle. The movements are done incrementally using a for loop in the function of Arduino. The for loop inputs the step angle and the rest duration to reach every incremented angle. Demonstrated prototype of the shake table in this study defines four main parameters needed to control the harmonic movements using a sine function. These parameters are programmed in Arduino ide as:

- Starting angle *(involves the min angle which is in line with the shake table first boundary)*
- Target angle *(defines the max angle also the second boundary of the shake table)*
- Step angle *(determines the step angle for each increment)*
- Step duration *(the duration needed for each step angle)*

By properly controlling these four parameters it is possible to generate different frequencies of dynamic motions. Entire code is written in C++ programming language and the response of the shaking table is analyzed in detail.

3. RESULTS AND DISCUSSION

The shaking table presented in this study can generate different frequencies and amplitudes based on the component limitations. The frequency and amplitude control are maintained based on the four parameters introduced before. Within the given configurations, the maximum frequency responses are about 13 Hz at the amplitude of ± 0.5 mm. The maximum stroke of the shaking table in one axis is ± 9 mm.

While conducting the harmonic movements in different frequencies and amplitudes, the following graphs have been obtained.

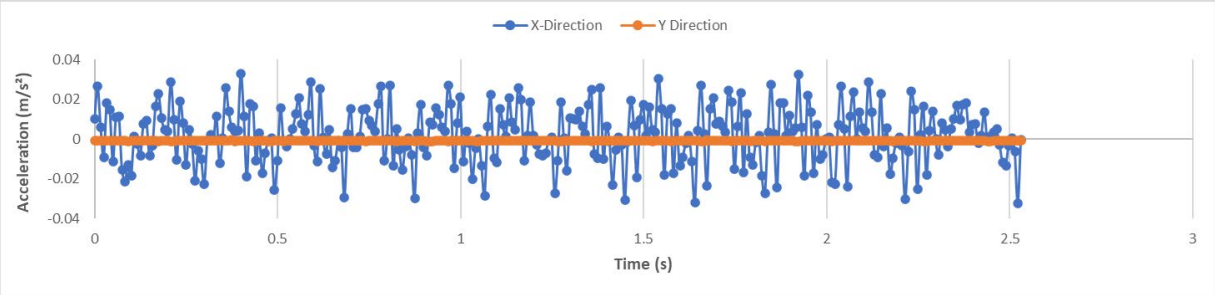
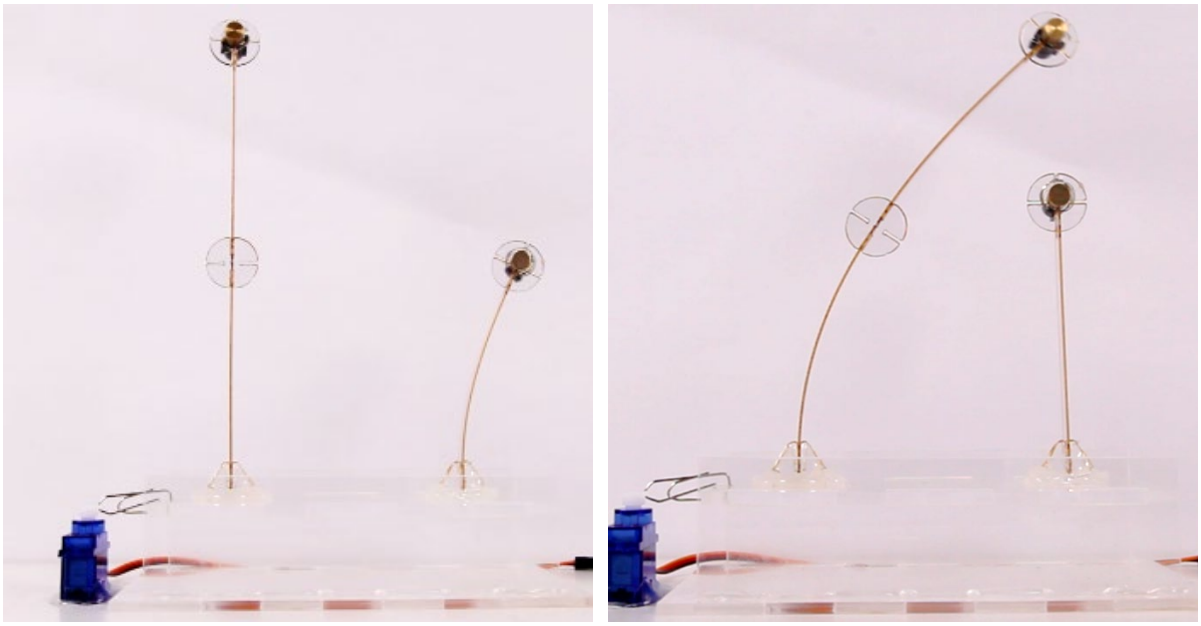


Figure 3. Acceleration of Harmonic Motions from the shaking table at frequency 5.12 Hz, a) acceleration in X-direction and b) acceleration in Y-direction

The accelerations gathered from the sensor show a level of noise in both directions. This happens due to the friction of plexiglass plates as well as motor imperfections. Nevertheless, while comparing the noise from one axis to another one, it is shown that the acceleration of y-axis which is in the perpendicular direction of the movements is about 50 times smaller than the acceleration of the x-axis. This demonstrates a good correlation of the signal and noise ratios for frequency 5.12 Hz.

Additionally, another target of the study is to demonstrate the behavior of the building and resonance effects. The resonance effect can have a significant impact on buildings and other structures. Resonance occurs when an object vibrates at its natural frequency, which can be caused typically by dynamic, earthquake forces. The resonance can cause structural damage, particularly if the frequency of the external force matches the natural frequency of the building. This can cause the building to vibrate more strongly, leading to fatigue and potentially causing structural failure. In this study the resonance effect is demonstrated using single degree of freedom structures with lumped masses. The natural frequency of the structures used is matched by the frequency of the table using an iterative process while changing the values of the parameters affecting the frequency of the base-table. Figure 4a and 4b show the resonance of two different structures at 5.12 Hz and 1.46 Hz respectively. Structures used during the tests were developed by another project at Epoka University [23].



a) Resonance demonstration of short SDOF building b) Resonance demonstration of long SDOF building

Figure 4. The developed shake table prototype.

4. CONCLUSION

In this study a methodology is presented on the mass-production of the small-scale, single-axis, low-cost shake table. The dynamic movements and excitations are provided by the servo motor. The controlling of the motor is done using Arduino UNO. To validate the noise caused by the unclearness while preparing the components of the prototype in laser cutting machine, the MPU6050 accelerometer sensor is used. From the output values it is seen a good correlation between the signal and noise ratio. In addition, two single degree of freedom (SDOF) structures with lumped masses are used to demonstrate the resonance effect. By properly configuring the parameters coded in the algorithm of shaking table it was possible to achieve a good resonance for both buildings. Therefore, it can be concluded that the mass-production of these under €40 devices are good tool for educational purposes in the area of earthquake engineering.

REFERENCES

[1] Elnashai A.S., Sarno L.D.,, "Fundamentals of Earthquake Engineering," John Wiley & Sons, Ltd., 2008.

[2] Aliaj Sh., Koçiu S., Muco B., Sulstarova E.,, "SEISMICITY, SEISMOTECTONICS AND SEISMIC HAZARD ASSESSMENT IN ALBANIA," Akademia e shkencave e Shqiperise, 2010.

[3] L. S. Jacobsen, "Vibration research at Stanford university," Bulletin of the Seismological Society of America 19.1, pp. 1-27, 1929.

[4] X. Lu, G. Fu, W. Shi, and W. Lu., "Shake table model testing and its application," The Structural Design of Tall and Special Buildings, pp. 181-201, 2008.

[5] A. Bogdanovic, Z. Rakicevic, and E. Noroozinejad Farsangi., "Shake table tests and numerical investigation of a resilient damping device for seismic response control of building structures," Structural Control and Health Monitoring, 2019.

[6] Z. Rakicevic, A. Bogdanovic, E. N. Farsangi, and A. SivandiPour., "A hybrid seismic isolation system toward more resilient structures: Shaking table experiment and fragility analysis," Journal of Building Engineering, 2021.

[7] Benedetti D, Carydis P, Pezzoli P, "Shaking table tests on 24 simple masonry buildings," Earthq Eng Struct Dyn, 1998.

[8] Kim SE, Lee DH, Ngo-Huu C, "Shaking table tests of a twostory unbraced steel frame," J Constr Steel Res, 2007.

[9] Ozcelik O, Luco JE, Conte JP, "Identification of the mechanical subsystem of the NEES-UCSD shake table by a least-squares approach," J Eng Mech , 2008.

[10] Zhang R, Lauenstein PV, Phillips BM , "Real-time hybrid simulation of a shear building with a uni-axial shake table," Engineering Structures, 2016.

[11] Yang TY, Li K, Lin JY et al , "Development of highperformance shake tables using the hierarchical control strategy and nonlinear control techniques," Earthq Eng Struct Dyn, 2015.

[12] Saranik M, Lenoir D, Jézéquel L , "Shaking table test and numerical damage behaviour analysis of a steel portal frame with bolted connections," Comput Struct, 2012.

[13] Shao X, Enyart G, "Development of a versatile hybrid testing system for seismic experimentation," Exp Tech, 2014.

[14] A. Elgamal, M. Fraser, and F. McMartin., "On-line educational shake table experiments," Journal of Professional Issues in Engineering Education and Practice, 2005.

[15] AutoCAD, User's Guide, Autodesk inc., 2013.

[16] EasyCut, "Laser Machine User Manual: OPERATOR V1.0," CTR, 2018.

[17] T. SG90, "Micro Servo Datasheet," 2021.

[18] A. (n.d.)., "Arduino UNO Rev3," [Online]. Available: https://www.arduino.cc/. [Accessed February 2023].

[19] A. (n.d.)., "Arduino IDE," [Online]. Available: https://www.arduino.cc/en/software/. [Accessed March 2023].

[20] I. Inc., "MPU-6050 Product Specification.," 2011. [Online]. Available: https://www.invensense.com/wp-content/uploads/2015/02/MPU-6000-Register-Map1.pdf.

[21] S. Madgwick, "Serial Oscilloscope, XIO Technologies, 2013.," 2013. [Online]. Available: https://x-io.co.uk/serial-oscilloscope.

[22] Servo.h, "Arduino: Library. The Software Servo Library, Arduino," [Online]. Available: https://playground.arduino.cc/ComponentLib/Servo/. [Accessed 2023].

[23] Gerta Isufaj, Joana Biba, "APPLICATION OF A PRACTICAL METHODOLOGY FROM LAND SURVEYING TO ROAD DESIGN USING MODERN TOOLS," Epoka University, Tirane, 2022.

[24] AutoCAD, User's Guide, Autodesk inc., 2013.

Inundation Modelling Using Hec-Ras Software Farka Stream Case Study

Mirjeta Blloshmi[1]*, Miriam Ndini[1]

[1]*Department of Civil Engineering, Faculty of Architecture and Engineering, EPOKA University, Autostrada Tiranë-Rinas, km. 12, 1032, Tirana, Albania*
** Corresponding author: mblloshmi15@epoka.edu.al;*

ABSTRACT

This study analysis how water flow corresponding to maximum discharge of Q=240m^3/s is distributed along Farka stream. To visualize flow dispersion, two modelling approaches 1-dimensional and 2-dimensional HEC-RAS models are implemented and unsteady flow analysis is simulated. HEC-RAS models and hydraulic analysis are used to analyse water depth planimetry and flow hydrograph of each stream segment. The objective is to develop 1-dimensional and 2-dimensional models, representing possible stream rehabilitation scenario and performing unsteady flow analysis in order to make a comparison of results. In this study, it is concluded that flow distribution along stream was not the same for 1 and 2-dimensional models. These two modelling approaches, under the same conditions, produces different results and only engineering experience together with project aim can decide which one of them to use while performing flood modelling.

Keywords: *Rehabilitation, Unsteady Flow, Hydraulic Analysis, Flow Hydrograph, Simulation.*

1. INTRODUCTION

Throughout history flooding has proved to be one of the most devastating natural hazards all over the world due to intense distribution of water streams. Based on available data Albania is considered to be as high-risk region related to flooding [1] [2] [3]. The high probability of flooding events has developed the necessity for flood protection. There has been a great, consistent effort to comprehend, rate and anticipate flooding events and their effect. Several studies have been conducted related to flood modelling, their priorities and their deficiencies also. It is crucial to have a clear understanding of flood modelling approaches and to precisely distinguish them from one another. Only in this way the selection of the appropriate model will be easier [4] [5] [6] [7] [8].

2. FLOOD HISTORY OF THE STUDY AREA

In year 2011 a government investment was made with the intention to rehabilitate the stream bed, by constructing a concrete covered trapezoidal cross section into the stream covered with concrete at a length of 140m, and by implementing a culvert with dimensions base b=5m, height h=3m and length l=90m to pass near the State Reserve Depots. Trapezoidal cross section has suffered numerous damages and water has found its path outside banks of stream.

The most critical discharge was registered on 30 November 2014, which based on the maximum water level measurements turns out to have been Q=240m^3/s. This unusual discharge caused considerable damage to the left concrete covered stream bank and to the bad of the stream.

The temporary interventions in Farka stream could neither provide an effective protection for the stream itself nor for the abovementioned structures located there.

In order to provide an effective and efficient evaluation of the Farka stream rehabilitation this project is based on 1-dimensional and 2-dimensional flood modelling.

3. RESEARCH DOMAIN

Figure 1 presents the location of Farka stream. In this study Farka stream is divided into three segments that are used as checking points to compare the results of unsteady flow simulation of each corresponding model. Topographic data figure 2 (a), required for modelling were obtained from topographic measurement of the area done by MANETCI Company and reference system used was WGS 1984/UTM zone 34. Besides HEC RAS software, ARC-GIS was used to generate 3-dimensional terrain model.

Furthermore, the same boundary conditions were used to perform 1D and 2D unsteady flow analysis. Flow Hydrograph and Normal Depth were used respectively as upstream and downstream boundary conditions. Also, the data from 1 in 100-year repetition flow hydrograph figure 2 (b), generated from hydrological analysis of the study area, performed by other researchers, was used as an input in HEC RAS hydraulic modelling, to perform unsteady flow analysis.

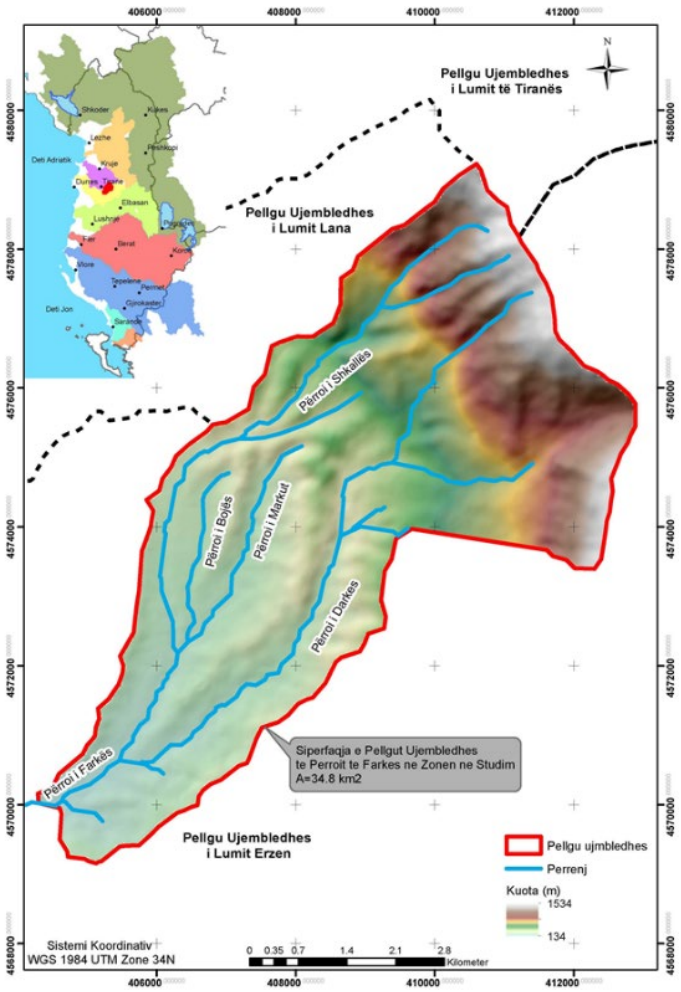
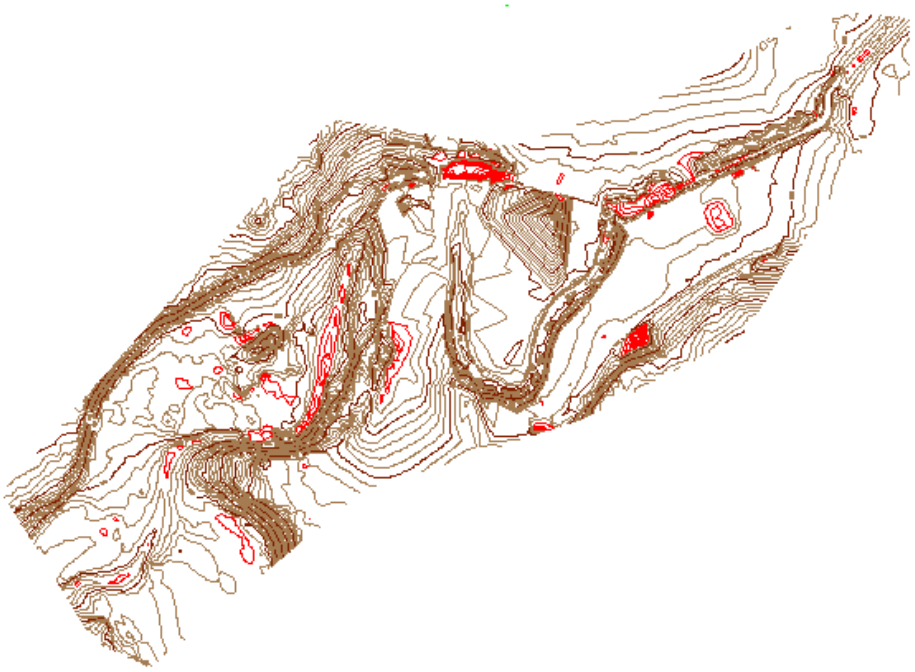
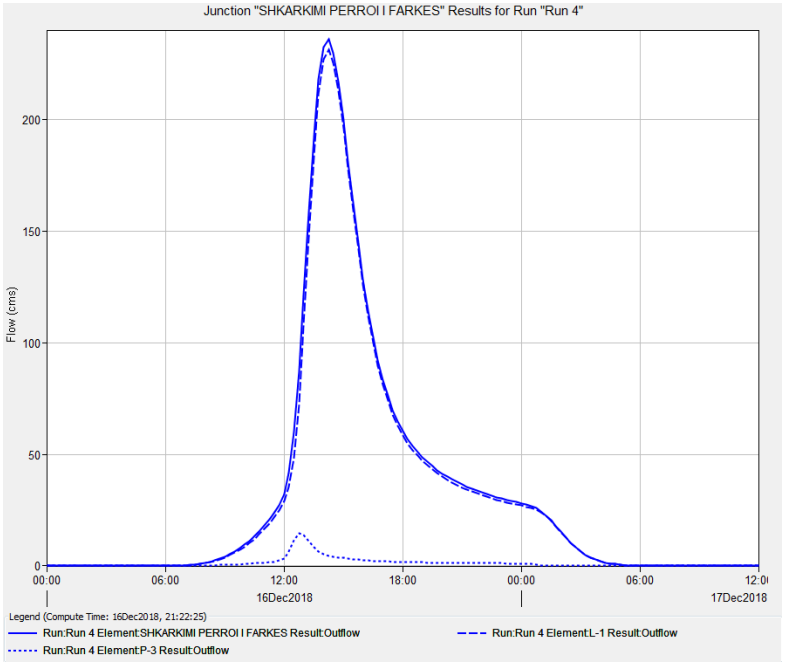


Figure 1. Location of the Case Study, Farka Stream



(a)

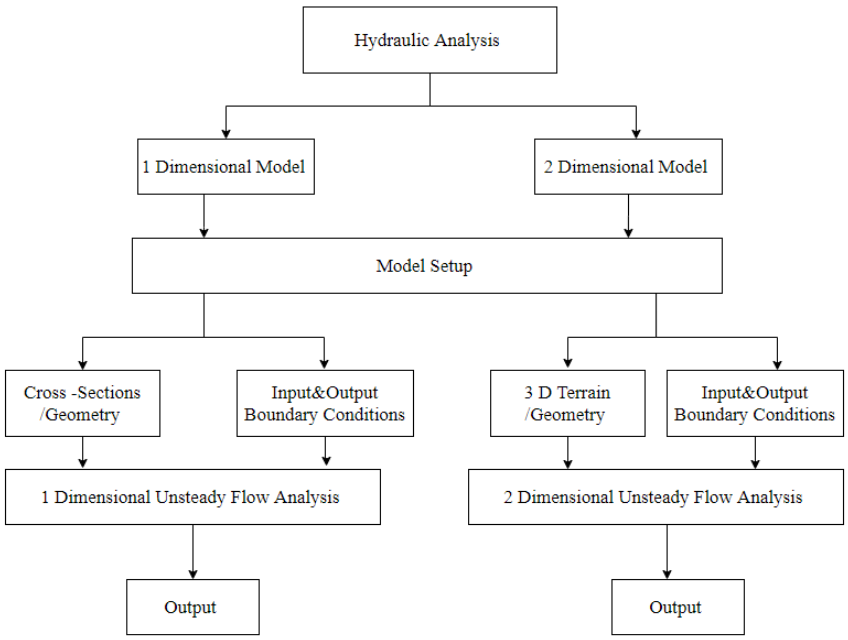


(b)

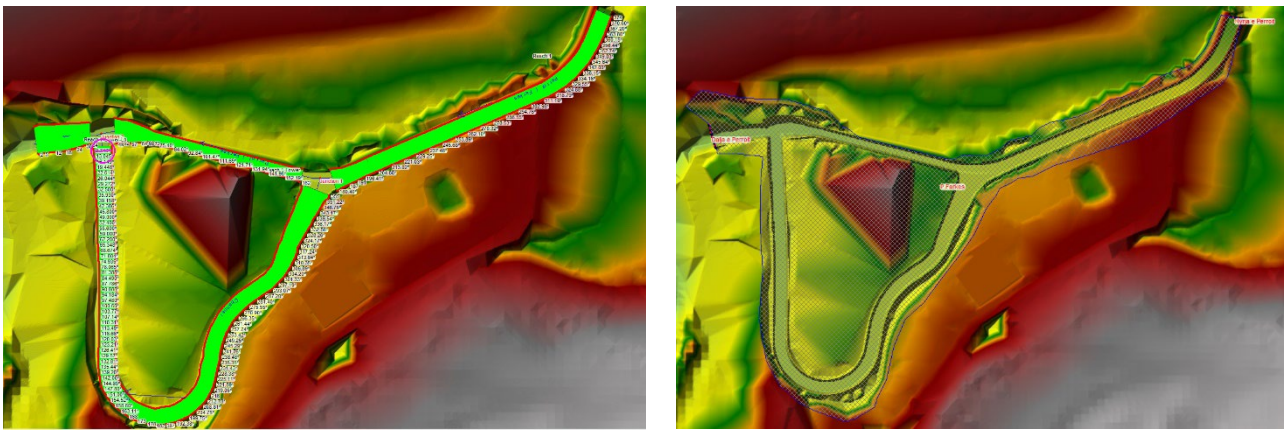
Figure 2. (a) Topographical Data of Area Under Study, Farka Stream, (b) Hydrograph of Farka Stream, 1 time in 100-year repetition, Q=236m^3/s

4. METHODOLOGY

Different procedures were followed do develop 1-dimensional and 2-dimensional models [9] [10], figure 3 (a). As 1-dimensional model is more cross section-oriented modelling approach, attention was paid to cross section implementation also, junctions along the stream were carefully defined, figure 3 (b). Meanwhile, to set up 2-dimensional model, 2D flow are was developed, figure 3 (c). After specifying upstream, downstream boundary conditions the simulation of unsteady flow was performed and results related to water depth planimetry, flow hydrographs were obtained for both models. In this way the accuracy of each model and their capability could be rated. [11], [12], [13], [14]



(a)



(b) (c)

Figure 3. (a) Flowchart of Hydraulic Analysis of Modelling Approach Using HEC-RAS 5.0.7, (b) 1D Model Setup, Cross Sections, Junctions, (c) 2D Model

5. RESULTS AND ANALYSIS

In order to study whether the flow inundated the rehabilitated channel for both models and also to interpret flow distribution on junctions for 1-dimensional model and flow distribution along stream for 2-dimensional model, it was important to carefully interpret the results obtained from the simulations. Water depth planimetry represented the distribution of water into the channel and the areas nearby it and visualizes if the water inundated the area or not. Moreover, three segments were defined on each corresponding part of the stream and for each segment there were obtained results corresponding to flow capacity.

The simulation is developed based on maximum water flow 240m^3/s which occurs 1 in 100 years, generated from the hydrological study.

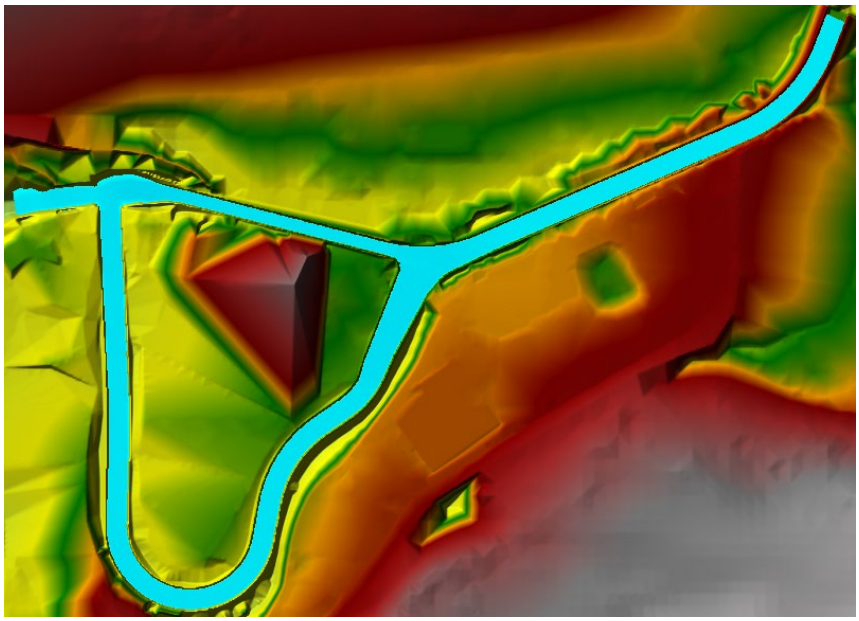


Figure 4. Water Depth Planimetry, 1-Dimensional Model

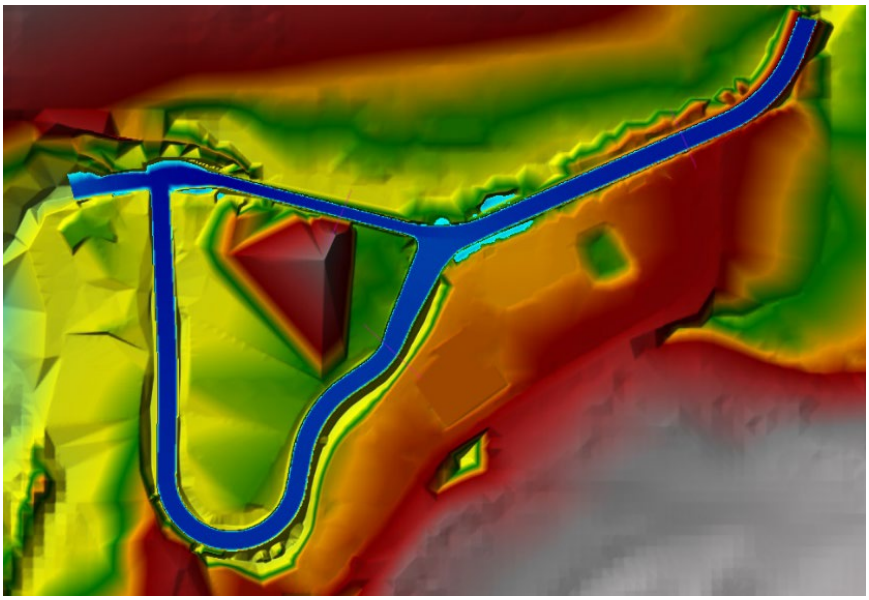


Figure 5. Water Depth Planimetry, 2-Dimensional Model

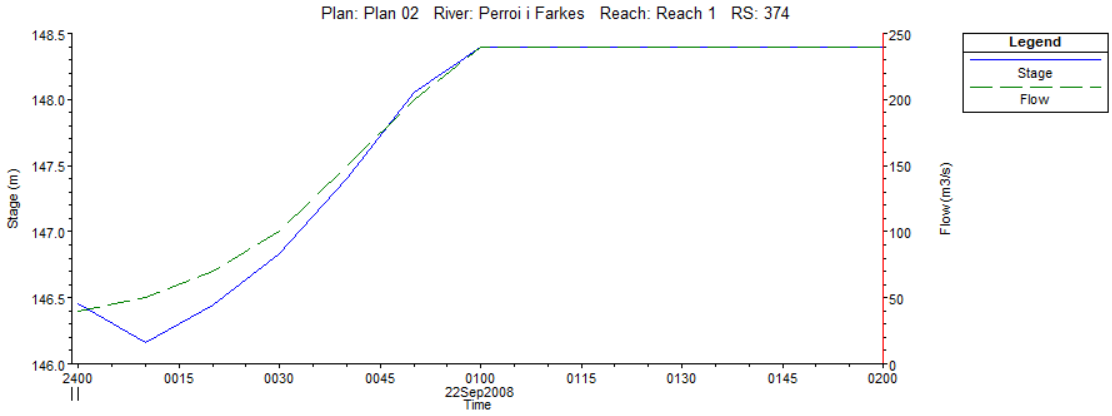


Figure 6. Stage & Flow Hydrograph, Q=240m^3/s, Section 1, 1-Dimensional Model

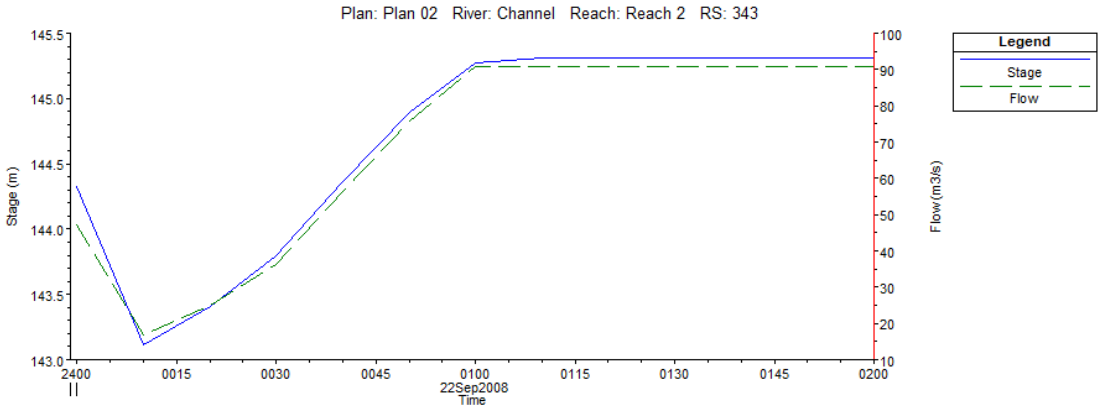


Figure 7. Stage & Flow Hydrograph, Q=90.91m^3/s, Section 2, 1-Dimensional Model

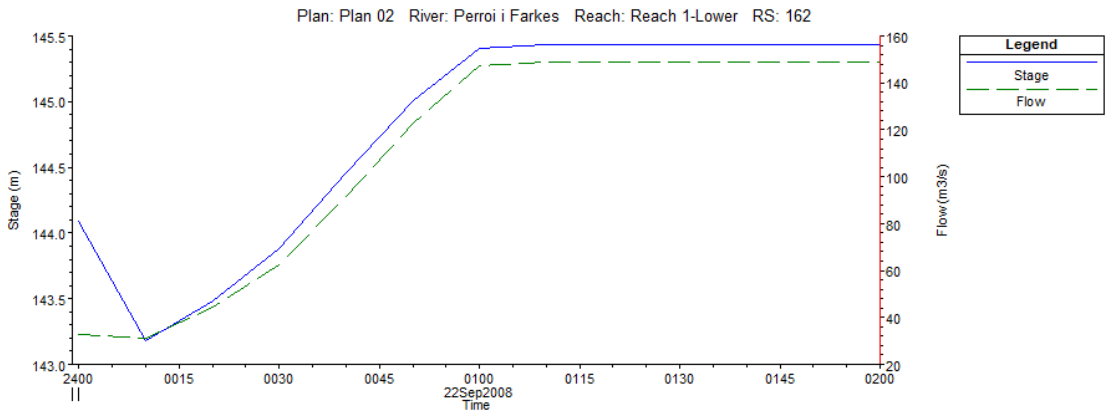


Figure 8. Stage & Flow Hydrograph, Q=149.09m^3/s, Section 3, 1-Dimensional Model

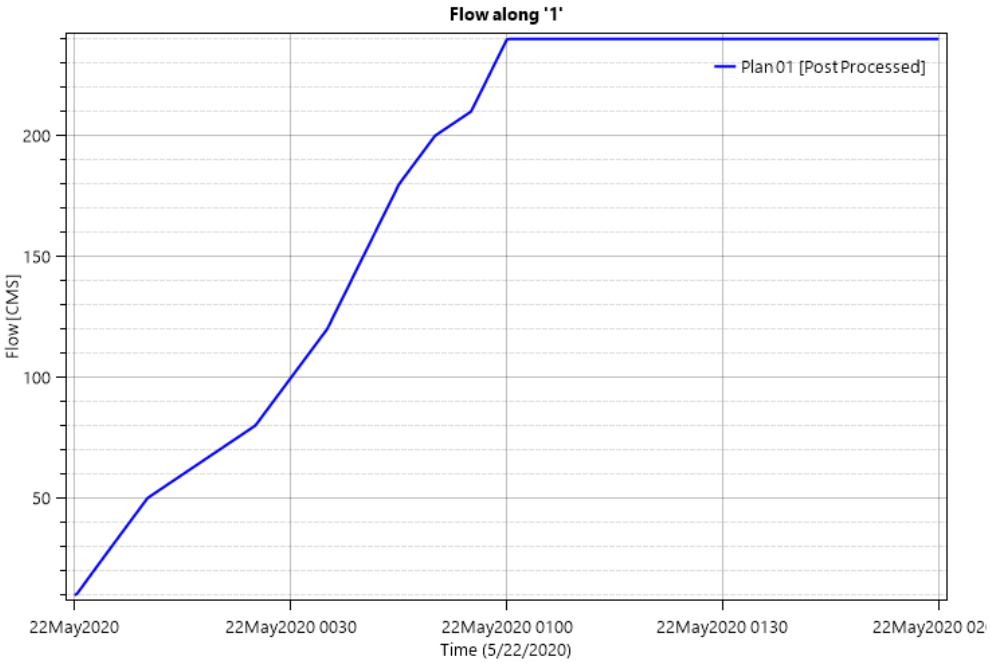


Figure 9. Flow Along Section 1 Q=240 m^3/s

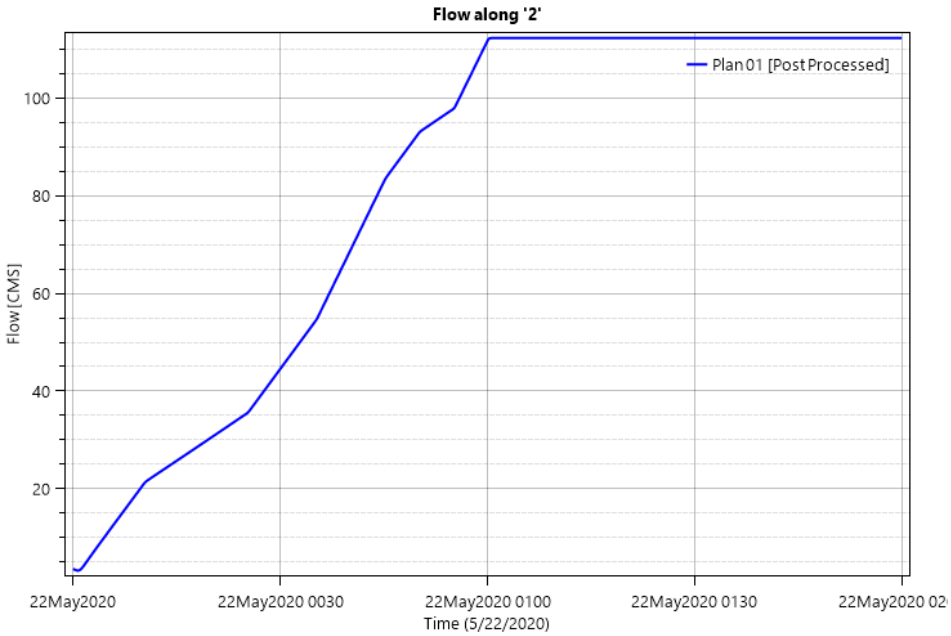


Figure 10. Flow Along Section 2 Q=112.3 m^3/s

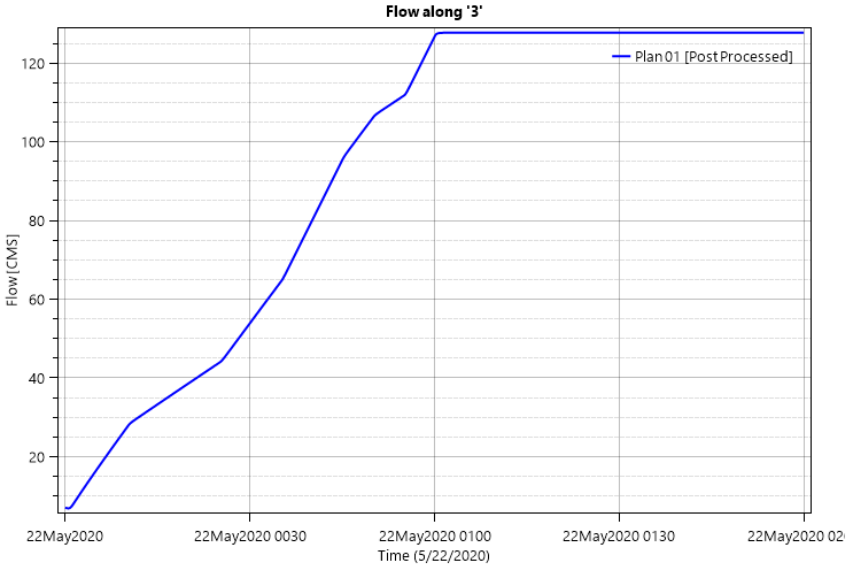


Figure 11. Flow Along Section 3 Q=127.7 m^3/s

The result generated from 1-dimensional model, Figure 4 (Figure 4), is similar to water depth planimetry received from 2-dimensional model, Figure 5 (Figure 5). In both cases, the area, under the specified conditions is not inundated.

Continuing with, Flow Hydrograph, Figure 6 (Figure 6), Figure 7 (Figure 7), Figure 8 (Figure 8) and Figure 8 (Figure 8), the primary water stream known as 'Reach1', Figure 6 (Figure 6), corresponding to segment 1 has a discharge of Q=240 m^3/s, maximum discharge. This segment is reconstructed with a rectangular cross section BXH=8x3m. This segment ends into a split junction that reorganizes water flow into, 'Reach 2' corresponding to segment 2, Figure 7 (Figure 7), and 'Reach 1-Lower'corresponding to segment 3, Figure 8 (Figure 8), where the flow distribution is Q=90.91m^3/s and Q=149.09m^3/s respectively. Even thought, segment 2 has the same cross section as segment 1 the flow will not be the same in both of them. Segment 3, where a culvert of dimensions BxH=5x3m, will provide a stream with optimal conditions for the water to flow there.

Considering flow hydrograph of 2D model, Figure 9-10-11 (Figure 9-10-11), the primary water stream corresponding to segment 1 has a discharge of Q=240 m^3/s, maximum discharge, segment 2 and segment 3 the flow distribution is Q=127.7m^3/s and Q=112.3m^3/s respectively. Even thought, segment 2 has the same cross section as segment 1 the flow will not be the same in both of them. Segment 3, where a culvert of dimensions BxH=5x3m, will provide a stream with optimal conditions for the water to flow there. In all three segments water flow does not overcome the limits of each segment.

Water flow distribution, in both models Figure 6 (Figure 6), Figure 7 (Figure 7), Figure 8 (Figure 8), Figure 9 (Figure 9), Figure 10 (Figure 10) and Figure 11 (Figure 11) is not as consistent. Comparing both models, segment 2 and 3 differs with ± 21.39 m^3/s flow capacity.

6. CONCLUSION

In the presented study, hydraulic analysis was provided to perform a comparison of 1-dimensional and 2-dimensional flood models. Unsteady flow analysis was simulated under the same boundary conditions for both 1-dimensional and 2-dimensional models. These two models were compared to each other, in terms of water distribution along stream in order to define their capability and accuracy.

Moreover, results obtained from 1-dimensional model, did not align with results obtained from 2-dimensional model. Two modelling approaches showed that, under the same boundary conditions, the proposed rehabilitation case offered valid conditions to prevent flooding of the area around, Farka stream. But, on the other hand, the flow distribution along streams changed for both models.

1-Dimensoional and 2-dimensional HEC-RAS models, can both be efficiently used for flood mitigation. However, selection of appropriate model strongly depends on project aim. Further studies are required to be conducted in order to clearly define project characteristic linking it to the most realistic modelling approach.

REFERENCES

[1] I. F. o. R. C. a. R. C. Societies, "Albania Floods," DREF operation, 2010.

[2] E. &. D. M. ,. &. M. M. Toto, "Mbledhja e të Dhënave Historike të Humbjeve në Shqipëri".

[3] D. Vogli, "Gazeta Dita," 2 December 2017. [Online]. Available: http://www.gazetadita.al/veshtrim-mbi-permbytjet-me-syrin-e-nje-eksperti-shqiptar/.

[4] A. K. A. &. A. M. Selenica, "Risk assessment from floodings in rivers of Albania," in *International Ballkans Conference on challenges of Civil Engineering, BCCE,*, Tirana, 2011.

[5] L. &. D. B. G. Brandimarte, "Uncertainty in design flood profiles derived by hydraulic modelling," *Hydrology Research Journal ,* pp. 753-761, 2012.

[6] J. J. A. J. C. B. Teng, "Flood inundation modeling: A review of methods, recent advances and uncertainity analysis," *Environmental Modeling and Software,* p. 16, 2017.

[7] C. F. E. K. &. A. M. Y. Fosu, "RIVER INUNDATION AND HAZARD MAPPING," *Journal of Global Geospatial Conference,* 2012.

[8] C. B. &. N. V. Okoye, "MAPPING OF FLOOD PRONE AREAS IN SURULERE, LAGOS, NIGERIA: A GIS APPROACH," *Journal of Geographic Information System ,* vol. 7, pp. 158-176, 2015.

[9] F. A. &. B. J. P. Maniyar, "Literature study on hydraulic modeling of floodplain mapping," *International Journal of Research in Engineering Technology ,* vol. 4, no. 11, p. 5, 2015.

[10] U. K. N. M. &. R. H. Khalil, "Flood Mapping for Indus River: Chashma-Taunsa Reach," pp. 30-48, 2017.

[11] S. K.-A. C. M. B. A. &. B. U. Gülbaz, "zFlood Modeling of Ayamama River Watershed in Instambul, Turkey," *Journal of Hydrologic Engineering,* pp. 1-10, 2019.

[12] G. W. Brunner, HEC-RAS River Analysis System Users Manual, 2016.

[13] G. W. Brunner, HEC-RAS, River Analysis System Hydraulic Reference Manual, 2016.

[14] C. Goodell, "The RAS Solution," 23 May 2011. [Online]. Available: https://www.kleinschmidtgroup.com/ras-post/modeling-junctions-for-unsteady-flow-analysis/.

Parametric Study of the Effects of Seismic Pounding between Residential Structures

Margarita Dajko[1], Huseyin Bilgin[1]*

[1]*Department of Civil Engineering, Faculty of Architecture and Engineering, EPOKA University, Autostrada Tiranë-Rinas, km. 12, 1032, Tirana, Albania*
** Corresponding author: hbilgin@epoka.edu.al;*

Abstract

During seismic vibrations several damages occur in the overall structure or in specific structural members. The damages are sometimes multiplied by the impact coming from the abutting buildings because of the insufficient distance in-between buildings. Usually, the most serious cases of collisions between structures are when buildings own different dynamic characteristics and structural damages to both structural and non-structural elements are multiplied during the impact of buildings. In seismic countries, it is essential to provide the necessary measurements to avoid the possible collision of buildings. In this paper, a parametric study is taken to recognize the factors that influence the displacement of structures the most. Two models of Reinforced Concrete buildings are prepared and different combinations of structural parameters are made to derive the needed conclusions of the study through a comparative evaluation.

Keywords: *Earthquake, Abutting Buildings, SAP2000, Reinforced Concrete Structures, Eurocode, Static Analysis.*

1. INTRODUCTION

During different periods of time several countries have witnessed calamities and severe damage arising during seismic events. One scenario that occurs during an earthquake is the non-synchronistical vibration of closely built structure, which is a result of the dynamic differences in the existing structures. Due to the displacement of buildings during vibrations and the lack of enough separation distance between these existing structures, pounding phenomenon happens. In some studies, the impact of buildings has been acknowledged as the primary cause for the collapse of the buildings. (Favvata M. J., 2015) Residential structures are often built near to one another, as in the cases of residential complexes or in highly populated cities, because of the high price for land usage. So, as a result, structures have often been found to pound with each other during the response to seismic ground motions. The insufficient separation distance is not only due to the high cost of the land, but also because the previous seismic code provisions did not provide specific guides to calculate the most probable minimum building separation gap needed to prevent pounding.

Albania is located in one of the most active seismic regions of Europe and it is classified as a moderate seismic country. As buildings in this country are prone to frequent earthquake ground motions, seismic pounding is a phenomenon that can occur whenever the safety separation gap between adjacent buildings is not properly provided (*Figure 1*).

Figure 1. Pounding development due to higher modes of vibration in Durres Earthquake of 2019 (Lekkas, Mavroulis, Filis, & Carydis, 2019)

In this paper, the minimum separation space between two adjacent reinforced concrete buildings is evaluated using linear static analysis. Buildings represent two existent buildings with different storey numbers, modelled in SAP2000 as two-dimensional frames. The parameters evaluated in the study include seismic zone factor, concrete class and floor height. Ten structures combinations are modelled and linear static analysis is performed for the general and fast evaluation of separation distance in-between the structures.

Assessment of separation space is made by using four different code approaches, including Eurocode 8, which is applied in the latest Albanian practices. A comparison with Albanian Seismic Code (KTP-89) provisions is made, as this code is still being used. The characteristics of the earthquake loadings are adopted with the conditions in Albanian region.

2. MATERIALS AND METHODS

2.1. Selection of buildings and Modelling Parameters

Two existing RC adjacent buildings with different heights, G+11 and G+7, with an initial separation gap of 10 cm, are considered for the study of the effect of pounding under seismic loadings (*Figure 2*). The buildings modelled are two symmetric eleven storey and seven storey RC residential buildings with equal storey height. They are designed as 2D frame models with fixed supports at the ground level *(Figure 3).* SAP2000 v.16.0.0 is used to run the linear static analyses. Three general cases for the parametric study are followed.

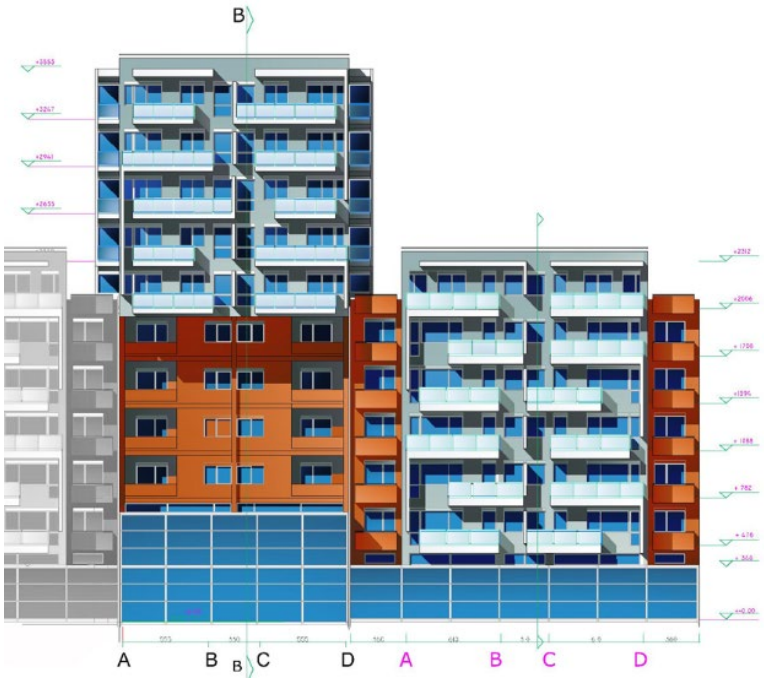


Figure 2. Front view of the adjacent buildings

In the first case, three concrete classes (C) are considered; C20/25, C25/30 and C30/37. For two other cases, C is taken as C25/30. While, for the second case, the influence of the seismic zone factor (Z) on separation gap is taken into consideration. The selected factors are 0.30, 0.25, 0.20 and 0.15.

Lastly, for the third case, the change of separation gap with the storey height is observed, where three different storey levels 2.8m, 3.0m and 3.5m are chosen.

The heights of each storey are considered to be the same in both structures. For the first and the second case, the heights are 3.0 m.

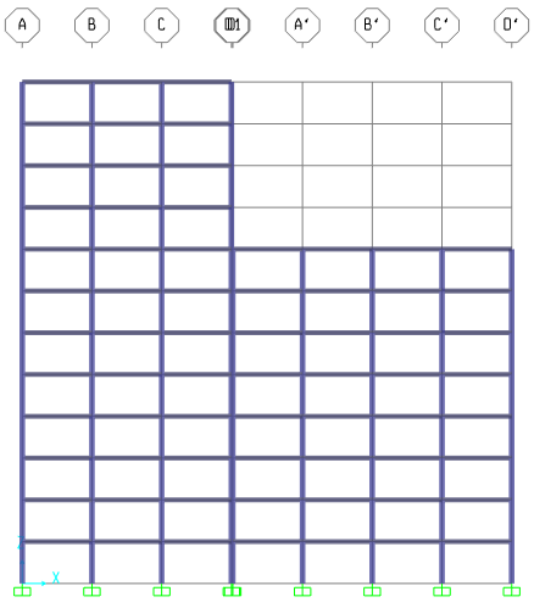


Figure 3. Two-dimensional frame structures modelled in SAP2000

2.1.1. Structural Modelling

Two representative R/C frames of structures are modelled in SAP2000 by using the technical plans of the buildings. The frame is assumed to be supported on soil of class C, according to Eurocode classifications.

Cross section reinforcement of the elements is designed according to Eurocodes' requirements. Steel bar class is S500. The thickness of the slabs is considered to be 15 cm. The concrete unit weight is taken as 25 kN/m^3.

After the frames of both buildings are drawn in SAP2000, load patterns are defined (*Figure 4*). The frames are loaded under the dead loads (DL), live load (LL), wall load (WL) and earthquake loads (EQ). According to Eurocode, the loads are combined as in the following equations:

$$[\boldsymbol{DL + EQ}] \quad (1)$$

$$[\boldsymbol{DL + EQ + 0.3LL}] \quad (2)$$

$$[\boldsymbol{1.35DL + 1.5LL}] \quad (3)$$

$$[\boldsymbol{DL + 1.5LL}] \quad (4)$$

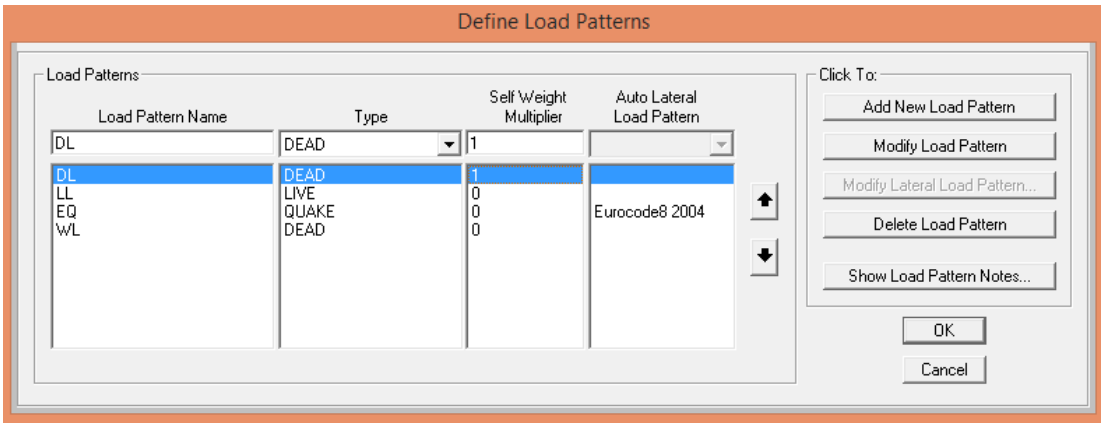


Figure 4. Load Pattern Definition in SAP2000

3. RESULTS AND DISCUSSION

In this paper, all two-dimensional representing models and analysis are performed in SAP2000, where structures are loaded under DL, LL and EQ combinations, as it is indicated in Euro 2-2004. Different evaluations for separation gap through square root of the sum of squares method (S_{SRSS}), absolute sum method (S_{ABS}), IS1893, 2016 provision $S_{q*(ui+uj)}$ and FEMA 356 maximum SG S_{max}, are done. The calculations for each evaluation methods for SG are tabulated in the table. N_1 and N_2 are the numbers of storeys of the buildings.

From the results in the Table 1, the SRSS method estimates the minimum values of SG, but it is not an adequate approach to follow in case out of phase vibrations occur simultaneously. So, for a safer evaluation, the S_{ABS} method is used to calculate the optimal SG. The $S_{q*(ui+uj)}$ and S_{max} give overestimated amount of SG, which is not convenient due to limitations of land usage. So, for the graphs and results, the S_{ABS} numerical values are used. The separation gap provision calculation according to KTP-89 is also evaluated, to check and compare the results with Eurocode and other provisions.

Absolute sum method: $[SG = u_i + u_j]$ (5)

Square root of the sum of squares: $[SG = \sqrt{u_i^2 + u_j^2}]$ (6)

Square root of the sum of squares: $[SG = \sqrt{u_i^2 + u_j^2}]$ (7)

(Khatami, Naderpour, Barros, & Jankowski, 2019)

The Indian Standard IS 1893:2016 states that the seismic gap between two adjacent structures is equal to the response reduction factor (which in Eurocode 8 is denoted by letter "q") times the sum of floor displacements u_i and u_j of the buildings. The default value of the reduction factor in Eurocode 8 for R/C ductile buildings is equal to 6, while in the Albanian Earthquake Resistant Design Regulations 1989, the reduction factor is 5. (Sanchez-Ricart, 2010)

According to KTP-89, the minimum seismic joint is calculated with the following formula (Qendra Sizmiologjike & Drejtoria e Projektimeve, 1989):

$[SG= u_i+u_j+2cm]$

where SG is the separation gap, u_i is the maximum displacement of building 1 and u_j is the maximum displacement of building 2.

According to KTP-89, the SG should fulfil the followings:

$[SG \geq h/250]$ *and* $[SG \geq 3cm]$ (8)

where h is the height of the shortest building.

Table 1 Calculation for Separation Gap

Building Combination	*C*	*Z*	*H*	*N1*	*N2*	S_{ABS} *(cm)*	S_{SRSS} *(cm)*	$S_{q*(ui+uj)}$ *(cm)*	S_{max} *(cm)*
1	20	0.25	3.0	12	8	11.3907	8.967373	68.3442	96
2	25	0.25	3.0	12	8	11.2834	8.896947	67.7004	96
3	30	0.25	3.0	12	8	11.2322	8.840752	67.3932	96
4	25	0.30	3.0	12	8	13.6723	10.76199	82.0338	96
5	25	0.25	3.0	12	8	11.2834	8.896947	67.7004	96
6	25	0.20	3.0	12	8	8.987	7.072979	53.922	96
7	25	0.15	3.0	12	8	6.8367	5.3795	41.0202	96
8	25	0.25	2.8	12	8	9.2692	7.292811	55.6152	89.6
9	25	0.25	3.0	12	8	11.2834	8.896947	67.7004	96
10	25	0.25	3.5	12	8	13.3747	10.68654	80.2482	112

where C is concrete class, Z is seismic zone factor, H is storey height, N1 is the number of storeys for building 1 and N2 is the number of storeys for building 2.

Table 2 Calculation for Separation Gap according to KTP-89

Building Combination	*C*	*Z*	*H*	*N1*	*N2*	*KTP-89 (cm)*
1	20	0.25	3.0	12	8	13.3907
2	25	0.25	3.0	12	8	13.2834
3	30	0.25	3.0	12	8	13.2322
4	25	0.30	3.0	12	8	15.6723
5	25	0.25	3.0	12	8	13.2834
6	25	0.20	3.0	12	8	10.987
7	25	0.15	3.0	12	8	8.8367
8	25	0.25	2.8	12	8	11.2692
9	25	0.25	3.0	12	8	13.2834
10	25	0.25	3.5	12	8	15.3747

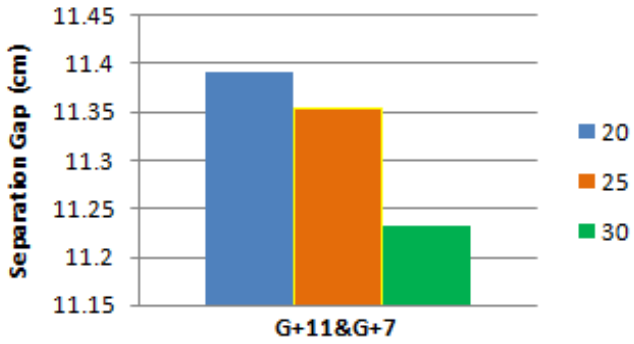


Figure 4. Variation of SG with concrete class

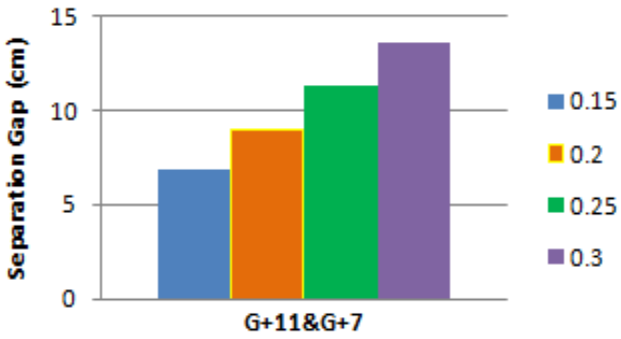


Figure 5. Variation of SG with seismic zone factor

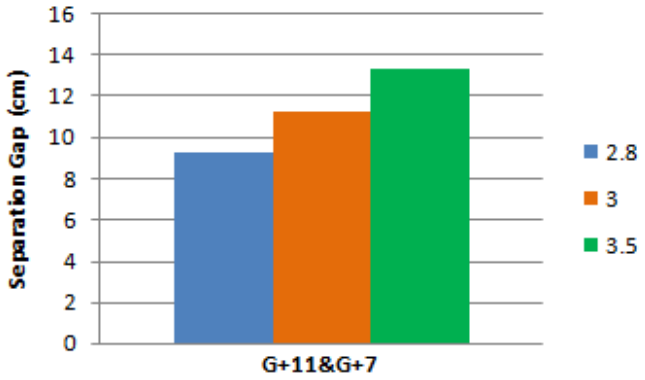


Figure 6. Variation of SG with storey height

By comparing all the results coming from the cases, the most critical case is considered the one with the highest seismic zone factor. Due to the large impact, both buildings suffer greater damages during the earthquake. So, in order to prevent serious damages, the provision of sufficient SG is very crucial while designing adjacent structures.

4. CONCLUSION

In order to avoid the seismic pounding, which is a serious issue during an earthquake, a solution for such problem is the provision of a safe separation gap between adjacent structures. For that reason, the main attention of the work has been to evaluate the minimum separation gap which provides enough security and safety during seismic vibrations of adjacent structures.

- It has been noticed that in most of the studies and code provisions, SG is evaluated based on the overall elevation of buildings, meanwhile this study gives an emphasis in the influence of other parameters such as concrete class, seismic zone factor and storey height. By analyzing these parameters in the buildings, it is concluded that with their variation, the SG changes as well.
- It can be noticed that by increasing the concrete class (C), the SG between adjacent structures decreases. Even though providing a higher concrete class will reduce the spacing of separation gap, for construction companies this approach might increase the total cost of the project, which is not convenient, especially for Albanian practices.
- The required SG calculated by using IS1893, 2016 provision $S_{q^*(ui+uj)}$ and FEMA 356 maximum SG S_{max} overestimate the required SG, which is not convenient for land usage and cost.
- The closest building combination for the existing set of buildings is the combination 2. Since the existent buildings are designed and constructed based on Eurocodes, the SG of the adjacent buildings is calculated using SRSS method. For building combination 2, according to SRSS method, the SG is 8.896947cm while, the actual separation joint between the structures is 10 cm. This means that the model results are in consonance with the real provided gap.
- The KTP-89 provision from Albanian Seismic Design Code requires a minimum separation gap that is larger than Eurocode minimum requirements. From the safety perspective we can say that the Albanian practice provides a safer seismic joint, but from the economic perspective we would say that it is more costly to implement it due to high price of land usage.

REFERENCES

[1] Khatami, S., Naderpour, H., Barros, R., & Jankowski, R. (2019). Verification of Formulas for Periods of Adjacent Buildings Used to Assess Minimum Separation Gap Preventing Structural Pounding during Earthquakes. *Advances in Civil Engineering*.

[2] Lekkas, E., Mavroulis, S., Filis, C., & Carydis, P. (2019). The September 21, 2019 Mw 5.6 Albania. *Newsletter of Environmental, Disaster*.

[3] Qendra Sizmiologjike, A. e., & Drejtoria e Projektimeve, M. e. (1989). *Kusht Teknik Projektimi per Ndertimet Antisizmike KYP-N.2-89.*

[4] Sanchez-Ricart, L. (2010). Reduction factors in seismic codes: On the components to be taken into account for design purposes. *Georisk Assessment and Management of Risk for Engineered Systems and Geohazards*, 208-229.

Preparing the 21st Century Professionals for the Execution of Major Infrastructure Projects in Western Balkans

Željko Torbica[1]*, Zoran Cekić[2]

[1]*School of Construction Management Technology, Purdue University, Lambertus Hall, Room 4240, West Lafayette, IN 47907, USA*
[2]*Faculty of Informatics and Computing, Singidunum University, Danijelova 32, Belgrade, Serbia*
* *Corresponding author: ztorbica@purdue.edu;*

Abstract

This paper analyzes the ever-increasing needs for infrastructure projects in the Western Balkans, summarizes the availability and nature of prospective future funding sources, and takes a critical look at the readiness of the regional Architecture, Engineering, and Construction (AEC) community to successfully deliver these, traditionally, very complex projects. The paper argues that there is a gap between the needed level of expertise (knowledge, skills, and abilities) and the current level that is available in the regional AEC eco-system. The paper concludes by suggesting several long- and short-term solutions for closing that gap.

Keywords: *Western Balkans, Infrastructure Projects, Construction Management.*

1. INTRODUCTION

Construction is the largest industry in the global economy, accounting for 13 percent of the world's GDP. Despite its enormous size and economic importance, the industry has a record of consistently underperforming on a number of important operational metrics. For example, the industry's annual productivity growth over the past 20 years has been only a third of total economy averages [1]. A poor performance record is particularly evident for the complex construction megaprojects including major infrastructure projects, and naturally, these problems are even more pressing in small developing economies such as the Western Balkans. There are many reasons for this disappointing state. The authors argue that one of the reasons is the lack of adequate expertise (knowledge, skills, and abilities) on the part of various "decision makers" who are involved in the process of conceiving, selecting, front-planning, execution, and eventual operation and maintenance of megaprojects. The paper is mainly concerned with the execution phase of the megaproject (i.e., the selection of the "right" project has already been made by decision makers) and the ways the construction management professionals, especially the ones who have come through traditional engineering or construction management educational paths, can further develop the expertise that is needed for successful delivery of infrastructure projects.

2. NEEDS FOR DESIRABILITY, AND FUNDING OF INFRASTRUCTURE PROJECTS IN WESTERN BALKANS

An analysis of current trends in population and urbanization shows an increased need for infrastructure expansion and renewal. McKinsey analysis found that $69.4 trillion in global infrastructure investment would be needed through 2035 to support expected GDP growth [1]. In terms of "desirability", for policy makers, investment in infrastructure megaprojects has always been particularly attractive, because, if properly done, such investment (i) creates and sustains employment, (ii) contains a large element of domestic inputs relative to imports, (iii) improves productivity and competitiveness by lowering producer costs, (iv) benefits consumers through higher-quality services, and (v) improves the environment when infrastructures that are environmentally sound replace infrastructures that are not [2]. Western Balkans economies are no exception. Figure 1, below, summarizes national investment priorities for addressing large infrastructure bottlenecks in the region. Improving transport infrastructure (roads and railways) and upgrading energy generation capacity is the common goal for the entire region [3].

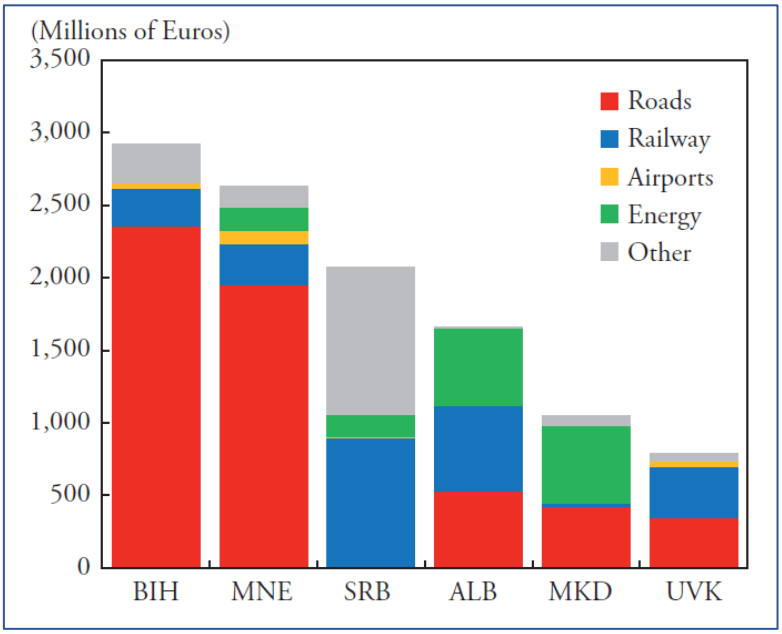


Figure 1. National investment priorities in Western Balkans [3]

To build much needed infrastructure projects in the Western Balkans remains dependent on loans granted by the European Union and a group of individual states, mainly, China, Russia, and Turkey. In 2018, the European Union put into action its Instrument for Pre-Accession Assistance (IPA) program to finance infrastructure projects in the Western Balkans. The primary mechanism for upholding Western Balkan infrastructure investments is the Western Balkans Investment Framework (WBIF) whose primary goal consists in integrating funds from various sources, including individual states and the European Union [4]. Up to €30 billion ($31.8 billion) is expected to be put at the service of recovery, economic development and green transition in the Western Balkans between 2021 and 2028, out of which €9 billion ($9.53 billion) will be grants provided by the European Union [5]. These are very significant investments, given the relatively small size of the Western Balkans economies (see Table 1 below).

	POPULATION Millions	GDP (2018) $ Billions	GDP Per Capita $	GDP Weight Western Balkans %	GDP Weight Europe %
Albania	2.88	38.3	$13,330	14.4	0.13
Bosnia and Herzegovina	3.51	44.6	$12,724	17.7	0.16
Kosovo	1.96	19.6	$10,515	7.8	0.07
North Macedonia	2.1	31.0	$14,914	12.7	0.11
Montenegro	0.68	11.1	$17,736	4.4	0.04
Serbia	7.00	117.8	$16,493	43	0.39
	18.13	**262.4**		**100**	**0.9**

Table 1. Western Balkans population and GDP [4,6]

China has been a major player in offering loans that do not require any additional legal or environmental conditions, as it can be seen from Table 2 below.

Country	Year	Contractor	Sector	USD mn
BA	2010	Dongfang Electric	Energy	710
BA	2013	Power Construction Corp	Energy	280
BA	2014	China Energy Engineering	Energy	1,060
BA	2015	Dongfang Electric	Energy	460
BA	2017	Shandong Gaosu	Transport	640
MK	2013	Power Construction Corp	Transport	400
ME	2014	China Communications Construction	Transport	1,120
RS	2010	China Communications Construction	Transport	260
RS	2010	Sinomach	Energy	340
RS	2013	China Communications Construction	Transport	850
RS	2013	Shandong Gaosu	Transport	330
RS	2013	Sinomach	Energy	720
RS	2016	China Communications Construction	Transport	230
RS	2016	Sinomach	Energy	230
RS	2016	Huawei	Technology	170
RS	2016	China Comm. Constr. and China Railw. Eng.	Transport	160
RS	2016	Power Construction Corp	Transport	220
RS	2017	Shanghai Electric	Energy	210
RS	2017	China Communications Construction	Transport	520
RS	2017	Power Construction Corp	Energy	230

Note: These projects are not FDI, but mostly public investment contracts financed by Chinese banks; not all the projects might be realised.
Source: China Global Investment Tracker, January 2018.

Table 2. Chinese firms' major construction contracts: 2010-2017 [7]

In order to guarantee a successful utilization of major international financial resources, each country is placed under a constant watch to demonstrate the capability for successful delivery of complex and costly infrastructure projects. For example, consequences of special laws drafted to contract infrastructure projects and absence of a national development plan in Serbia, political prioritization of highway tracks in Kosovo, alternative national project pipelines in Montenegro, low quality of project preparation in North Macedonia, environmental impact in Bosnia, substantial use of PPP and change of project parameters in Albania are

some of the questions that were raised and discussed in the Civil Society Forum organized in Berlin in June 2021 [5].

3. IS WESTERN BALKANS READY FOR MAJOR INFRASTRUCTURE PROJECTS?

Major infrastructure projects, be it a dam, a high-speed train, or a major highway, affect every citizen on a daily basis. Moreover, when these megaprojects go wrong, whole companies and national economies are affected. The consequences from building the wrong projects, or building projects wrongly are enormous. Disappointingly, a vast majority of megaprojects, irrespective of the geographic location, type of project, or the economic wellbeing of the country in which it was built, have a poor record. The world's most renowned expert on megaprojects, Dr. Flyvbjerg, describes this dismal performance as the "Iron law of megaprojects: Over budget, over time, under benefits, over and over again" [8]. In his own words, in the area of management of megaprojects "best practice is an outlier, and average practice is a disaster" [8]. Nevertheless, a significant amount of knowledge about megaprojects has been accumulated and it should be used to inform policy, practice, and public debate in this very costly area of government and business [9].

Public expectations are that the decision makers who are involved in any of the life-cycle phases of a megaproject (i.e., conceiving, selecting, front-planning, executing (building), operating and maintaining) be well qualified for these important roles. In this paper we raise the following question: do we have enough qualified professionals who are ready and capable to successfully execute (i.e., "build") major infrastructure projects? What is the capacity of the local Architecture, Engineering, and Construction (AEC) community to deliver these complex projects? Is there a gap between the required (needed) and the actual competencies of professionals involved in delivering infrastructure projects? And if there is a gap, what are some possible solutions for closing it?

Local AEC market structures in the Western Balkans are characterized by a fragmented landscape (both vertically and horizontally) of mostly small companies with limited economies of scale. That was not always the case. For example, former Yugoslavia, where many of the Western Balkan countries used to belong, was a major global AEC powerhouse. A number of its companies were successfully competing for international projects with some of the world's best AEC companies, and several companies were consistently included in the annual Engineering News Record's (ENR) rankings. For example, Energoprojekt, the most celebrated company from the region, was ranked #6 globally in the Construction Management category (1979) (while Bechtel (USA) was ranked #50); 20 in the Turnkey Contracts category (1979), and #16 in the General Building Contracts category. Currently, Energoprojekt is the only company from the region still included in the ENR rankings, ranked #121 in design, and #226 in construction [10, 11], a far worse performance than what it was during its "golden" years. In addition to industry defragmentation, other negative developments have also been in place, such as the rapid loss of accumulated state-of-the-art know-how due to a natural attrition process (retirement of the most experienced cadre), a significant exodus of top talent ("brain drain"), the diminishing quality of received education, and the reduced interest in construction from the prospective top talent students.

All of these suggest that the regional AEC eco-system doesn't have capacity to deliver major infrastructure projects by its own cadre. Instead, most (if not all) of the major infrastructure projects are

delivered by one of the major global players with the participation of local companies playing a smaller role. A number of international companies from the 2022 ENR Top 250 (contractors) and Top 225 (designers) lists are currently involved in projects in the Western Balkans (see Table 3 below). This list does not include international companies that didn't appear on the ENR ranking lists, so the total number of international companies is most likely greater than the one reported in Table 3.

	# of Top ENR Companies Working In <CONTRACTORS>	# of Top ENR Companies Working In <DESIGNERS>	# of Top ENR Companies From <C: Contr./D: Designer>
Albania	7	24	0
Bosnia and Herzegovina	9	24	0
Kosovo	(not included)	(not included)	(not included)
North Macedonia	8	10	0
Montenegro	(not included)	(not included)	(not included)
Serbia	22	37	1/1

Table 3. 2022 ENR Top international companies present in the Western Balkans [10, 11].

4. CONCLUSIONS AND RECOMMENDATIONS

According to the Oxford Handbook of Megaprojects Management [9] megaprojects are a completely different breed of project in terms of their level of aspiration, stakeholder involvement, lead times, complexity, and impact, and, therefore, they are a very different type of project to lead. More bluntly, the reference suggests that "conventional project managers should not lead megaprojects". Recognizing that there is ample of evidence supporting that notion, the authors of this paper agree that the current system of education and training is inadequate when applied to management of megaprojects, and that there is an urgent need for acquiring the expertise that is missing but critically important for successful delivery of major infrastructure projects.

The debate for the need to change to engineering education has been ongoing for several decades (at least in the United States). The result of that discussion has been numerous journal articles, reports and studies prepared by leading organizations, such as the American Society for Engineering Education (ASEE), the National Academy of Engineering (NAE), and the American Society of Civil Engineers (ASCE). Despite some implemented changes, many academicians and professionals are of opinion that the engineering curriculum of today still does not provide the foundation necessary to ensure the engineer's success in the 21st century [12]. Less robust discussion about the same concern, the adequacy of the curriculum, has been conducted in the academic field of construction management (CM), but similarly to the engineering community, many people still believe that, despite some incremental changes, the CM curriculum of today doesn't provide the foundation necessary to ensure the success in the 21st century. As we have previously discussed, looking at the performance of megaprojects, the overwhelming evidence supports the notion that both the current educational system and the industry practices are inadequate, at least for that segment of market. Some recommendations that can help bridge the expertise gap are listed below:

1. Increased study of the available state-of-the-art research on megaprojects. Currently, that subject is minimally studied in the engineering and construction management curricula, both in the United States and in the Western Balkans. Megaproject Planning and Management: Essential Readings [13] and the

Oxford Handbook of Megaproject Management [9] are excellent starting references. A stand-alone course at the undergraduate (preference) or graduate level would be a good start.

2. Next level would be, offering specialized undergraduate concentrations, and a specialized master program with the concentration on megaprojects.

3. A short continuous education course, offered by a university, a professional trade organization, or consultants, would be a good choice for practicing professionals. Companies should fund these courses. Delivery mode can be in-person, online, or hybrid.

4. Companies with less experienced staff should look for a partnership arrangements and collaboration with international companies that have more experience in delivering megaprojects. Exchanging professionals who may spend some time at each location may be an option.

5. To encourage that process, various professional organizations can introduce a formal certification program with a "megaproject professional" designation.

We have presented the case that: (1) the need for infrastructure projects, globally and in the Western Balkans, is ever growing; (2) the willingness of decision makers to consider pursuing major infrastructure projects remains to be very strong; (3) the funding opportunities are many and the future for funding appears promising; (4) the performance record for megaprojects has been and remains to be disappointing; and (5) the regional major infrastructure projects will continue to depend on major international AEC players. We have concluded by suggesting several short- and long-term solutions for the acquisition of this much needed expertise.

REFERENCES

[1] McKinsey & Company (2020) The next normal in construction: How disruption is reshaping the world's largest ecosystem.

[2] Helm, D. (2008) Time to invest: Infrastructure, the credit crunch and the recession. *Monthly Commentary*, 18 December, <http://www.dieterhelm.co.uk>.

[3] International Monetary Fund (2018) Public Infrastructure in the Western Balkans: Opportunities and Challenges.

[4] The Warsaw Institute Review (2019) Western Balkans: Infrastructure and Energy from a Geopolitical Perspective, Warsaw, Poland.

[5] Rexha A., Macura A., Krstinovska A., Hackaj A., Smolica G., Minic J., and Sosic M. (2021) Integrity compliance in Western Balkans infrastructure projects (accessed on March 4, 2023: https://www.euractiv.com/section/enlargement/opinion/integrity-compliance-in-western-balkans-infrastructure-projects/).

[6] International Monetary Fund (2017) World Economic and Financial Surveys, Regional Economic Outlook, Europe Hitting Its Stride.

[7] European Investment Bank (2018) Infrastructure Investment in the Western Balkans: A First Analysis.

[8] Flyvbjerg B. (2017) Chapter 1: Introduction: The Iron Law of Megaproject Management. In The Oxford Handbook of Megaprojects Management, edited by: Bent Flyvbjerg. Oxford University Press.

[9] The Oxford Handbook of Megaprojects Management (2017) Edited by: Bent Flyvbjerg. Oxford University Press.

[10] ENR (2022a) The Top 250, Number 32, August 22/29.

[11] ENR (2022b) The Top 225, Number 157, August 8/15.

[12] Galloway P. (2008) The 21-st Century Engineer. American Society for Engineering Education.

[13] Megaproject Planning and Management: Essential Readings (2014) Vols. 1-2 Edited by: Bent Flyvbjerg. Cheltenham, UK, and Northampton, MA: Edward Elgar.

Usage of Building Information Modeling (BIM) and Point Cloud for Post-Earthquake Damage Assessment: A Case Study from Albania

Izet Mehmetaj[1] *, Armela Kalliri[2], Miriam Ndini[1]

[1]*Department of Civil Engineering, Faculty of Architecture and Engineering, EPOKA University, Autostrada Tiranë-Rinas, km. 12, 1032, Tirana, Albania*
[2]*Faculty of Civil Engineering, Polytechnic University of Tirana, Tirana, Albania*
** Corresponding author: imehmetaj@epoka.edu.al;*

Abstract

Despite the adoption of numerous policies and measures by numerous governmental organizations in Albania, innovative approaches must be created to minimize additional risks after earthquake disasters by developing resilient-built environments. To improve risk assessment in post-disaster recovery operations, this study highlights the significance of implementing Building Information Modelling (BIM) data.

This study aims to develop a risk assessment tool for evaluating post-term earthquake damage using the affected area by the November 26th, 2019 earthquake in Albania as the primary case study.

The tool consists of combining spatial information from Building Information Modelling (BIM) with point cloud data from 3D laser scanning. The expected results of using the tool will facilitate the complexity and immediate urgency of engineering decision-making for building usage after a seismic disaster.

Keywords: *risk assessment, decision-making, earthquake, Building Information Modelling (BIM), point cloud.*

1. INTRODUCTION

In the aftermath of the Albania 2019 M_W=6.4 earthquake bringing focus to the topic of improving the existing damage assessment expertise, it has never been more necessary [1].

There is a lack of post-earthquake risk management systems in Albania and such a thing is not well-defined. No later than 2023, the National Civil Defense Agency of Albania (AKMC) has initially presented the Disaster Risk Reduction Action Plan for Albania 2023–2027, which predicts some various projects for the countermeasures for the future and economic losses that could result from damage to the buildings due to possible seismic events [2]. However, these projects seem to be inefficient considering the unpredictability of a seismic event or the fact that considerable time is required to be applied.

In this context, it is of interest to promote an integrated approach to risk assessment technology for earthquake-damaged buildings [1]. The purpose of the presented project is to provide a practical computer-based method for calculating and visualizing damages for post-earthquake building rehabilitation utilizing building information models (BIM).

Today, there is a lot of discussion over the advantages of BIM [3]. It has become widespread, typically as a result of some kind of standardization in all the stages of a project's life cycle including modeling, budgeting and quantity takeoff, time planning, and site investigation [3].

Combining spatial information from Building Information Modeling (BIM) with point cloud data from 3D laser scanning is not a new concept in Post-Earthquake Building Rehabilitation [4] [5]. Interests include mostly highlights on the risk management of historical properties [6].

The resulting model, which offers a realistic and thorough assessment of the risks to be absorbed by building owners, might become important in the communication between engineers and owners [7].

The followed methodology may serve as the foundation for earthquake damage assessments on existing buildings and can be utilized in any professional design office. As a primary case study will be the affected area by the November 26th, 2019 earthquake in Albania.

2. MATERIALS AND METHODS

2.1. BIM development model

The building is modeled using the Revit software. The original project that was implemented and the data that was extracted from on-site surveys served as the basis for the building modeling, including geometry and sections. The developed Revit model is displayed in Figure 1. There are two levels and a roof in this residential structure. The lateral loading is resisted by unreinforced masonry load-bearing walls in both directions.

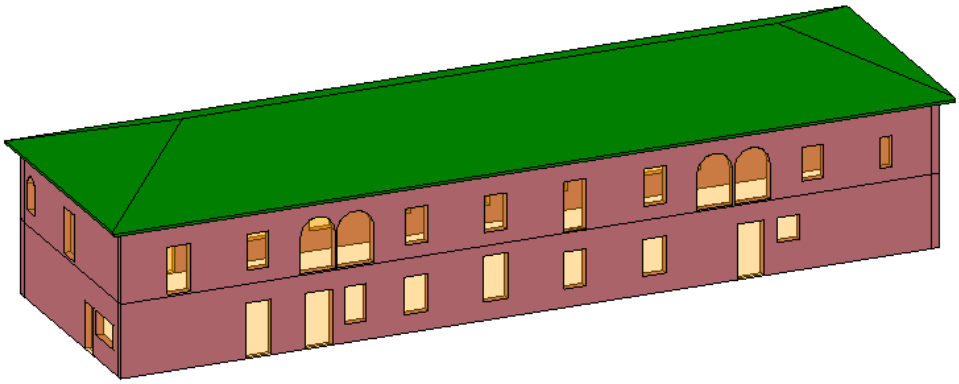


Figure 1. The developed BIM modelling of the building

2.2. Gathering of point cloud data

The campaign of topographical measurements for the building's verticality was conducted using the points/stations of polygonometry. The TOPCON GLS 1500 Scanner device was used to measure the verticality of the structure. By mounting the equipment on the building's perimeter roads, measurements were taken. The building's verticality was measured using a laser, which fixed all of its exterior facades to the "cross threads of the instrument" at each of its vertical peaks. The measurement was taken from the ground floor level (±0.00 m) to its top level. Scan Master (Mass 3D Point Cloud Acquisition and Processing) was used to process the scan's data.

Figure 2. 3D laser scanning obtained data

2.3. Combining point cloud data with BIM

To permit continued occupancy following the major earthquake of Albania in 2019, the external smoothness and slope of the building were examined as a verification scenario by merging the point cloud data obtained by 3D scanning with 3-D data.

Examining means comparing the two datasets to find variations in the general geometry using the same coordinate values. The point cloud data were utilized as a source of information after the occurrence of the earthquake, whereas the BIM data were used as a source of information before to the seismic event. In order to locate the point cloud and BIM data at the same coordinates, the data were merged. The structure's corners were chosen as the reference locations for the data combination.

Figure 3 displays the combination outcome using BIM data and 3D scanning.

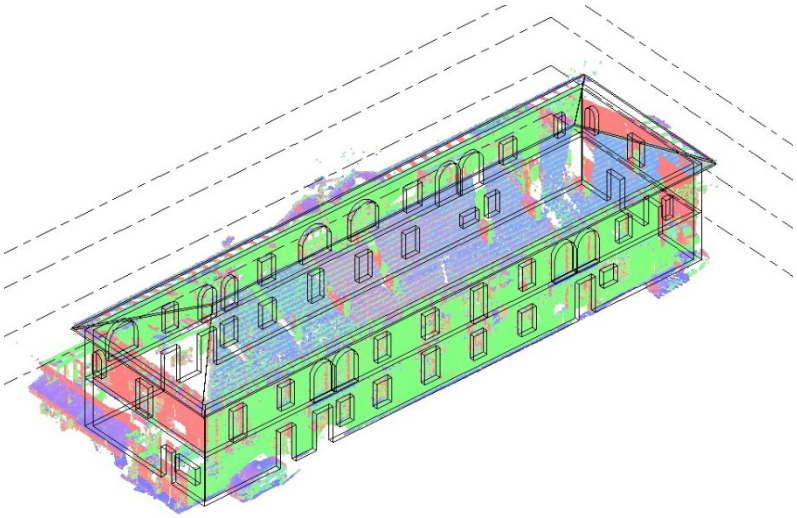


Figure 3. The combination of the two datasets

3. RESULTS AND DISCUSSION

By merging 3D measurement point data from the point cloud data with BIM design data, the flatness of the side walls was examined (Figure 4). It is discovered that the difference is 90 mm from the west side.

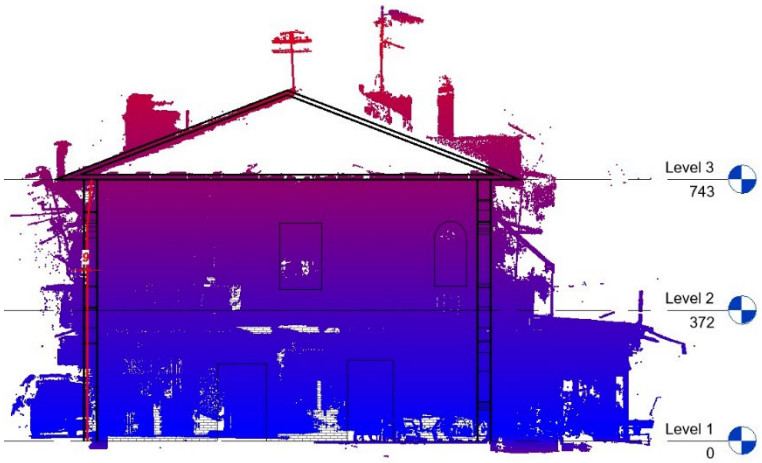


Figure 4. Smoothness analysis for the west side wall

Similarly, it was also measured how steep the building's total slope was in this side. The measurement indicated an inclination of 89.25° (Figure 5).

These results suggest that the structure is affected by any possible settlement, errors during the construction time or vulnerability to the seismic event.

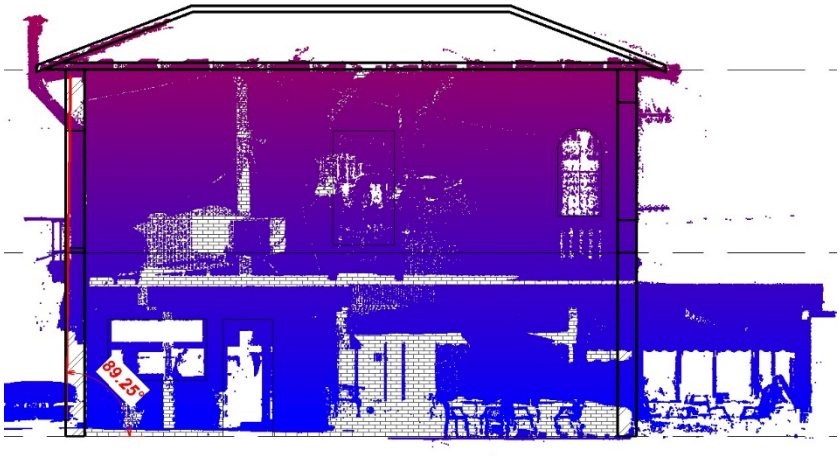


Figure 5. Building's total slope in the west side

4. CONCLUSION

This study aimed to develop a risk assessment tool for evaluating post-term earthquake damage using the affected area by the November 26th, 2019 earthquake in Albania as the primary case study.

The resulting approach showed that comprehensive seismic risk assessments can be made much more effective and practical by using BIM's ability to give easily accessible and in-depth information about structural and non-structural elements.

Making technical decisions for building usage following a seismic disaster is challenging given the situation's complexity and immediate necessity. The proposed methodology that can be applied to assess earthquake damage to existing buildings.

REFERENCES

[1] E. E. F. I. Team (2020) The Mw 6.4 Albania earthquake on the 26th November 2019, a field report by EEFIT. *Earthquake Engineering Field Investigation Team,* London.

[2] Agjencia Kombëtare e Mbrojtjes Civile (2022) Strategjia Kombëtare për Zvogëlimin e Riskut nga Fatkeqësitë, *UNDP in Albania*.

[3] David P. Welch, Timothy J. Sullivan, Andre Filiatrault (2014) Potential of building information modelling for seismic risk mitigation in buildings. *Bulletin of the New Zealand Society for Earthquake Engineering*, vol. 4, no. 4, pp. 253-263.

[4] Eun Soo Park, Hee Chang Seo (2021) Risk Analysis for Earthquake-Damaged Buildings Using Point Cloud and BIM Data: A Case Study of the Daeseong Apartment Complex in Pohang, South Korea," Sustainability, vol. 456, p. 13.

[5] Mohammad Ebrahim Mohammadi, Richard L. Wood (2018) Post-Earthquake Structural Damage Assessment Through Point Cloud Data, *Eleventh U.S. National Conference on Earthquake Engineering*, Los Angeles, California.

[6] C. Tommasi, C. Achille, F. Fassi (2016) From point cloud to BIM: a modelling challenge in the cultural heritage field. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, Vols. XLI-B5, pp. 429-436.

[7] Georgiou Charalambos1, Vamvatsikos Dimitrios2, Christodoulou Symeon3 (2014) Damage Assessment, Cost Estimating, and Scheduling for Post-Earthquake Building Rehabilitation Using BIM. *The Fourteenth International Conference on Computing in Civil and Building*, Orlando, USA.

Indicators of life expectancy – A Panel Data Analysis in EU countries

Melisa Huqi[1]*, Klaus Isku[1]*

[1]*Department of Banking and Finance, Faculty of Economics and Administrative Sciences, EPOKA University, Autostrada Tiranë-Rinas, km. 12, 1032, Tirana, Albania*
[*]*Corresponding Author: mhuqi19@epoka.edu.al; kisku19@epoka.edu.al;*

Abstract

The aim of this research paper is to examine the main indicators of life expectancy in all European Union Countries over the period 2001-2021 years. Based on the available scientific literature, the considered determinants are divided in the following categories: economic, social, environmental, technological and demographic factors. The empirical analysis consists of a panel data approach and a Fixed Effects Model is implemented on the regression composed of 8 independent variables. The main research question posed is to find out whether any of the regressors does have a significant impact on lifespan and to justify accordingly. The findings show that unemployment and CO_2 emission are found to have an insignificant impact on life expectancy. GDP, Urban Population and Health Expenditures tend to increase life-span in a significant way. On the other hand, results reveal that changes in Fertility Rate, Internet Usage and Inflation bring a decrease in a person's life duration. The only regressor that turned out to have an impact different from what was predicted is Internet Usage. This can be noted as a contribution driven by this paper, as technology is mostly valued for the innovations and easiness it brings to our lives, especially in developing or less developed countries, but in the case of EU countries it seems to have brought stress, lack of sleep, obesity and mental health issues to people and as a result ushers a decrease in happiness and the overall life satisfaction.

Keywords: *Life expectancy at birth, European Union, Internet Usage, CO_2 emission.*

1. INTRODUCTION

Life expectancy at birth is defined as the average number of years that a person is expected to live by keeping the mortality rate unchanged. Having said this, the crucial health achievement of the 20th century is the increase of lifespan of people living in developed countries with approximately 30 additional years (Christensen et al. 2009). The extension of lifespan and the natural decreasing trend of birth rates have brought a great challenge to the social security systems, with regard to financial aspects, to adapt the well-functioning retirement systems that would make it possible for 65-year old people to work beyond that age. This is absolutely in agreement with a dynamic strategy implemented on population from the perspective of increasing the life cycle (Zaidi 2014) and providing the elderly ones with the opportunity of giving their active input in labor markets – instead of disregarding their effort and influence on society. According to the statistics provided by Eurostat, the main countries within the European Union that had the largest level of life expectancy in 2020 were France, Spain and Greece in a descending order. Corsica's people were expected to live up to 84 years, the population of Balearic Islands 83.9 years and the one of Epirus around 83.8 years. Contrary to that, Bulgaria was the only country in the EU that had the lowest level of life

expectancy starting from the minimum of 72.1 years in the North-West regions and the maximum of 72.9 in the South-East regions. Furthermore, the latest database of the World Bank shows that the life of a typical male in the EU lasts up to 78 years while for a typical female it lasts up to 83 years. Behind these numbers do stand a wide range of indicators which play a crucial role in determining the increase or decrease of the expected average years for a person who lives in the specified area. Economic, social, technological, demographic and environmental factors interrelate with each other and trigger a range of effects that give an overall impact on the most important determinant of a nation's development which is life expectancy.

On this matter, the main objective of the study is to shed light on the essential factors that capture a significant impact on life expectancy at birth. The rest of the paper is organized as follows: chapter 2 scrutinizes the literature review of each single determinant, chapter 3 presents the methodology, chapter 4 focuses on empirical analysis and chapter 5 delivers the results and discussions. The last chapter provides conclusions and recommendations.

2. MATERIALS AND METHODS

2.1 Literature Review

The selection of the proper determinants varies from one paper to another, since it highly depends on data availability and preferred methodology of the author. The empirical studies of life expectancy, called the overall health status of the nation, are based on two strands: the first one has a concentration on macro data – for instance: Thorton (2002), Lichtenberg (2002), Shing-Jong (2009), Audrey (2004), Fayissa and Gutema (2005), whereas the second strand hinges on clinical and health-related aspects where implications of macroeconomic policy are hardly employed such as Nixon and Ulmann (2006) , Khuder (2001) who present a well-structured review on empirical analysis inspecting determinants by the close interconnection of health spending and health outcomes. Moreover, a nation's health status is either measured by life expectancy at birth, see for example Peltzman (1987) or at different age stratums as in the case of Miller and Frech (2000). Last but not least, empirical studies such as Halicioglu (2011) go along with a wide range of categories of determinants and are able to diversify the regression model by the involvement of economic, social, environmental, technological and demographic factors. In addition, Mariani et al. (2008) pays attention to environmental indicators, Berg and Nilsson (2009) investigate economic, social, political factors; Yavari and Mehrnosh (2006) concentrate on social and economic factors.

2.1.1 Gross Domestic Product

With regard to GDP, there have been conducted various studies and the majority of them emphasize that a significant positive relationship exists between GDP and life expectancy. Poças et. Al (2020) focuses his paper on a panel data approach of European Countries over the period 1990-2016 and through a Fixed Effects Model reveals that when the economy grows, the life span of individuals increases significantly. The same results are obtained from the empirical studies of James et al. (2017), Bilas et al. (2014) and Blazquez-Fernandez et al. (2017) who conclude that an increase in gross domestic product tends to extend the life span of the population. Contrary to these, Jafrin et al. (2021) finds that GDP is totally insignificant in explaining life expectancy based on a Random Effects Model on SAARC countries over the period 2000-2016. This finding is also in alignment with the paper of Kabir et al. (2008) who employs cross-section time series in 91 developing countries. Another interesting result is observed in the study of Hassan et al. (2017) which states that a bi-directional causality exists between life span and GDP only in the long-run. Lastly, an unconventional result is discovered in the study concentrated on Oman, during the period 1970-2012, on which Ali and Ahmad (2014) conduct an Autoregressive Distributed Lag model and surprisingly, GDP takes a negative sign, but appears to be statistically insignificant.

H_1: Gross Domestic Product has a significant effect on life expectancy.

2.1.2 Unemployment Rate

With respect to unemployment, a negative correlation with life expectancy is expected to happen based on the logical interpretation that most of the authors suggest, such as Monsef and Mehrjardi (2015) who investigates this relationship in 136 countries worldwide over the years 2002-2010 and their employed Fixed Effects Model demonstrates the afore-mentioned linkage between two variables. Conversely, the most unexpected finding is revealed in the paper of Blazquez-Fernandez et al. (2017) which lays out a positive impact of unemployment on life expectancy. On the other side, Tafran et al. (2020) examines 13 Malaysian regions over 2002-2014 through the implementation of a Fixed Effects Model and observes the unemployment rate to be a statistically insignificant factor in relation to life expectancy.

H_2: Unemployment Rate has a significant effect on life expectancy.

2.1.3 Urban Population

The impact of urban population, or the so-called urbanization, is discovered to be mostly positive based on a wide range of papers, but negative signs and insignificancy have been part of the literature review as well. Bayati et al. (2013) investigates such an impact through a Fixed Effects Model conducted on 21 Eastern Mediterranean Regions over the years 1995-2007 and concludes that urbanization does have a positive significant impact on life expectancy, similar to Monsef and Mehrjardi (2015), Azam et al. (2023), but not limited to. A completely different result is noticed in the study of Delavari et al. (2008) which brings to light an insignificant influence of urbanization on life span based on a time series OLS model in Iran over 1985-2013, similar to Kabir et al. (2008). At last, Jafrin et al. (2021) figures out a significant negative impact of urban population on life longevity.

H_3: Urban Population has a significant effect on life expectancy.

2.1.4 Carbon Dioxide Emission

The influence of carbon dioxide emission on life longevity is evaluated through different methodologies in literature – thus, the results derived are a bit perplexing. The paper of Ali and Ahmad (2014) aims at exploring such an impact by using a time series ARDL method and according to the outcomes CO_2 emission has a negative significant effect on life expectancy in the short-run and a positive, but insignificant effect in the long-run. Following the same methodology, Azam et al. (2023) highlights a significant and negative correlation, as well as Jafrin et al. (2021) and Poças et al. (2020) who come up with the same results in panel data approaches.

H_4: Carbon Dioxide Emission has a significant effect on life expectancy.

2.1.5 Total Fertility Rate

As already known, total fertility rate captures the average number of children that a typical woman within a population is expected to give birth to during her lifetime. The majority of authors among the literature review come to the same conclusion through their empirical analysis by detecting a significant negative relationship between total fertility rate and life expectancy. For instance, Jafrin et al. (2021) and Delavari et al. (2008) document this linkage via the respective findings.

H_5: Total Fertility Rate has a significant effect on life expectancy.

2.1.6 Internet Usage

Internet usage is considered to be the key regulator of our lives by providing improved access to health, ensuring patient care, delivering medical results in a prompt time and offering endless informative sources on different topics. Leung and Wang (2003) underlines his findings and states that when technology improves, economic growth is triggered, welfare increases and as a result, individuals will have the tendency to live longer. However, Jafrin et al. (2021) recognizes the insignificant impact of internet usage on life span of SAARC countries, which, according to him, seems to be inconsistent with the previous literature, but can be explained by the fact that these less developed nations do not frequently use the Internet for health-related activities. The other scenario which needs great attention is the negative impact that internet usage may have on people's lives. To support such a claim, Reinecke et al. (2016) develop their research paper based on a survey conducted in Germany and defend the tremendous significant negative impact that Internet usage does have on physical and mental health.

H_6: Internet Usage has a significant effect on life expectancy.

2.1.7 Inflation

The main cost of inflation is the deterioration of real income, which occurs when prices rise disproportionately and cause some customers' purchasing power to decline. A sharp decrease in the value of savings and pensions occur and economic growth slows. Monsef and Mehrjardi (2015) and Azam et al. (2023) point out that as prices rise, the ability to purchase lowers and correspondingly the impact of inflation on life span is shown to be negative and statistically significant. Contrary to this economic theory, Delavari et al. (2008) summarizes that inflation does have an insignificant influence on life longevity by indicating that its impact is not considerable at all in explaining the number of years individuals tend to live.

H_7: Inflation has a significant effect on life expectancy.

2.1.8 Health Expenditure

Spending on healthcare can lead to greater health opportunities being provided, which can enhance human capital and boost productivity. As long as individuals show great importance on health services, the healthier they will be and the longer they will live. In accordance with this, Poças et al. (2020) discovers a positive significant association between health expenditure and life expectancy in EU countries over 1990-2016. On the other hand, some unexpected results are obtained from the study of Bazquez-Fernández et al. (2017) and Jafrin et al. (2021), since in these papers health expenditure turns out to be unconventional as it has a negative sign and is at the same time statistically significant. Whereas Bayati et al. (2013) favorably reveals the insignificancy of health spending and it does have no impact on life span in spite of the negative sign. In contrast, Kabir et al. (2008) and Tafran et al. (2020) do also consider the demonstration of such an impact and from their findings an insignificant positive effect of health expenditure is interpreted.

H_8: Health Expenditure has a significant effect on life expectancy.

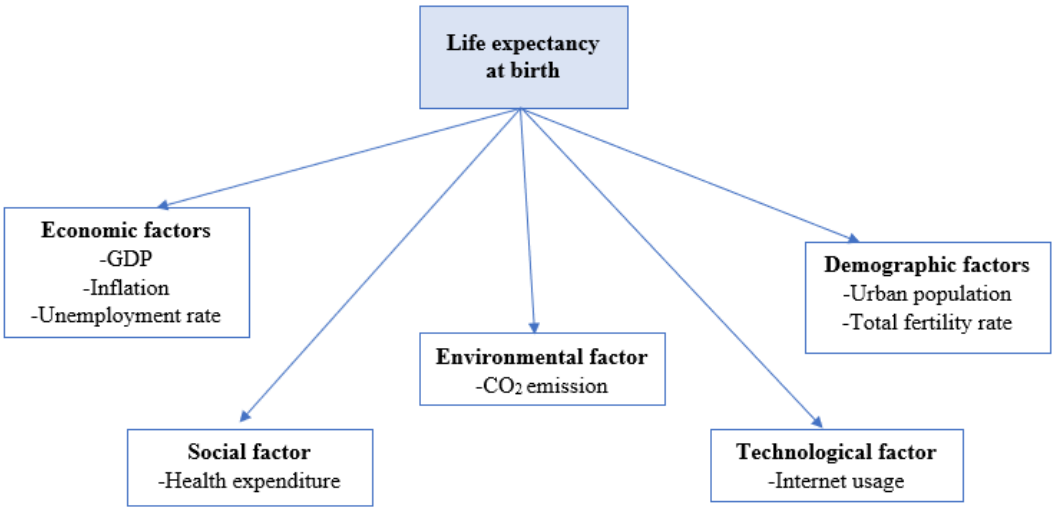


Figure 1. Diagnostic Framework

As presented in table 1, different authors explain the determinants of life expectancy at birth by using various econometric methodologies which vary from simple techniques of statistical descriptive analysis, general equilibrium framework composed of equations and formulas, following time series and panel data approaches. Fixed Effects Model, GLS model, Granger Causality, VECM, Engle Granger approach and ARDL are presented to be the most widely-used methods – hence, our study is endeavoring to come to some conclusions accompanying a Fixed Effects Model in which the parameters are fixed.

Table 1. Literature Review Summary

Author/s	Countries/Period	Methodology	Findings
Poças et al. (2020)	EU countries 1990 - 2016	Panel data: Pooled OLS and Fixed Effects Model	GDP and health expenditures have a significant and positive impact on life expectancy CO2 decreases life expectancy in a significant way
James et al. (2017)	35 OECD countries 1990 - 2015	GLS model	Health spending, GDP have a significant and positive impact on life expectancy; CO2's impact is totally insignificant.
Monsef and Mehrjardi (2015)	136 countries 2002 - 2010	Panel data: Fixed Effects Model	Inflation and unemployment affect life expectancy negatively Urbanization has a positive significant influence on life expectancy
Bayati et al. (2013)	21 EMR countries (Eastern Mediterranean Region) 1995 – 2007	Panel data: Fixed Effects Model	Co2 has an insignificant positive impact on life span Health expenditure has an insignificant negative impact on life span Urbanization and life expectancy have a positive relationship
Bilas et al. (2014)	28 EU countries 2001 - 2011	Panel data analysis and Granger Causality	A positive relationship between life expectancy and economic growth
Tafran et al. (2020)	13 Malaysian regions 2002 - 2014	Multivariate, cross-section and Fixed effect models	Unemployment is found to have an insignificant impact on life expectancy of males Health spending's effect is totally insignificant
Kabir (2008)	91 developing countries	Cross-country time series	GDP, urbanization and health expenditure have no significant influence on life expectancy
Hassan et al. (2017)	108 developing countries 2006 - 2010	VECM and Granger causality	Bi-directional causality between GDP and life expectancy in the long-run

Jafrin et al. (2021)	SAARC countries 2000 - 2016	Panel data: Random Effects Model and Pooled OLS	Total fertility rate, CO2 and urbanization negatively impact life expectancy GDP and internet usage are found to be insignificant Health expenditure turns out to be unconventional as it has a negative sign
Blazquez-Fernández et al. (2017)	8 OECD Asia and Pacific Area countries 1995 - 2013	Panel data: Multiple Regression Models	Unemployment rate and GDP extend the life expectancy in a significant way Health expenditure has a significant negative sign
Delavari et al. (2008)	Iran 1985 – 2013	Time series: OLS model and Engle Granger approach	Total fertility rate decreases the life span Urbanization, inflation was found to be insignificant CO2 has a positive sign but is insignificant
Leung and Wang (2003)	High and low-income countries	General Equilibrium Framework (A mix of equations and formulas)	Technology extends the life span by triggering economic growth
Azam et al. (2023)	Pakistan 1975 - 2020	Time series: ARDL	Inflation rate, CO2 negatively impact the life span GDP, health expenditure and urbanization affect it positively
Ali and Ahmad (2014)	Oman 1970 - 2012	Time series: ARDL	Inflation and GDP have a negative insignificant impact on life expectancy CO2 has positive & insignificant influence in long-run, and negative & significant impact in short-run
Reinecke et al. (2016)	Germany	Survey	Internet usage has a significant and negative impact on health and psychological issues, which as a result reduces the life span

The data is retrieved from World Bank Data Indicators, for 27 European Countries from 2001 until 2021. The dependent variable is life expectancy at birth and the independent variables are unemployment rate, gross domestic product, urban population, CO_2 emission, total fertility rate, internet usage, inflation and health expenditure. Through the implementation of a panel data analysis with the help of EViews program, Hausman Test determines that FEM (Fixed Effects Model) is the appropriate model for the regression. The methodology is based on some similar studies of previous authors such as Monsef and Mehrjardi (2015), Bayati et al. (2013) and most importantly Poças et al. (2020) who employ a Fixed Effects Model on EU countries, similar to our research.

2.2 Life Expectancy Function and Regression Model

LIFEEXP = f {unemp, GDP, upperc, co2em, tfr, internet, inflcp, hexp} (1)

$$lifeexp=\beta_0+\beta_1 unemp + \beta_2 GDP + \beta_3 upperc + \beta_4 co2em + \beta_5 tfr + \beta_6 internet + \beta_7 inflcp + \beta_8 hexp + u \quad (2)$$

($\mathbf{where}\ \boldsymbol{\beta_0}$ represents the intercept while **u** denotes the error term)

Table 2. Dependent and independent variables

Variables	Abbreviation	Measurement	Expected impact on Y
Life expectancy at birth (Y)	LIFEEXP	Measured in total years	
Unemployment	UNEMP	Measured as a percentage of the total labor force	- /no impact
Gross Domestic Product	GDP	Measured in USD	+
Urban population	UPPERC	Measured as a percentage of the total population	+
Carbon Dioxide Emission	CO2EM	Measured in tons per capita	- / no impact

Total fertility rate	TFR	Measured as a number of births per woman	-
Internet usage	INTERNET	Measured as a percentage of the population	+/-
Inflation (Consumer Price Index)	INFLCP	Measured as an annual percentage	-
Current Health Expenditure	CHEUSD	Measured in USD	+

2.3 Empirical Analysis

First and foremost, the variables must be free of unit root (Table 3). In order to test accordingly, the individual PP-Fisher Chi-square test is applied on the independent variables and Im, Pesar and and Shin W-stat test on the dependent variable. All the variables are found to be stationary in levels except for CO_2 emission and unemployment rate which do contain a unit root. Thus, they are checked in first difference and found to be stationary. Due to this fact, CO_2 emission and unemployment rate are modified and included in the regression as ''dunemp'' and ''dco2em''. Secondly, the Hausman Test is conducted to decide on which is the appropriate model (Table 6). The null hypothesis stands for a Random Effects Model and the alternative one for a Fixed Effects one. With a probability of 0, there is enough evidence to reject the null hypothesis and conclude that a Fixed Effects Model should be implemented. It is of crucial importance to make sure that the model is homoscedastic and does not suffer from serial correlation. To check for the first, White Test is carried out (Table 8), and for the latter AR (2) indicates that there is no serial correlation (Table 7). Furthermore, the correlations between independent variables do not exceed the threshold of 0.8 – thus multicollinearity assumption is as well fully satisfied (Table 9). The mean of residuals and the correlation of residuals with the regressors are very close to zero (Table 10) and, lastly, the model is normally distributed as illustrated from the probability value of the Jarque-Bera test (Table 11).

Table 3. Stationarity of independent variables in Levels

Variables	PP – Fisher Chi – square	Probability	Stationary in levels
unemp	52.3227	0.5393	Nonstationary
L(GDP)	365.197	0.0000	Stationary
upperc	1086.36	0.0000	Stationary
co2em	23.0396	0.9999	Nonstationary
tfr	93.5042	0.0007	Stationary
internet	898.309	0.0000	Stationary
inflcp	189.744	0.0000	Stationary
Lcheusd	737.948	0.0000	Stationary

Table 4. Stationarity of nonstationary variables in First Difference

Variables	PP – Fisher Chi – square	Probability	Stationary in 1st difference
d(unemp)	150.070	0.0000	Stationary
d(co2em)	378.366	0.0000	Stationary

Table 5. Stationarity of the dependent variable

Variable	Im, Pesaran and Shin W-stat	Probability	Stationary in level
lifeexp	-1.58773	0.0594	Stationary at 90% Confidence Levels

Table 6. Hausman Test

Correlated Random Effects - Hausman Test			
Test period random effects			
Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	**Prob.**
Period random	224.256893	8	**0.0000**

Table 7. Serial Correlation

Dependent Variable: RESID01				
Total panel (balanced) observations: 432				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
DUNEMP	0.031876	0.012832	2.484046	0.0134
LGDP	-0.005792	0.015189	-0.381325	0.7032
UPPERC	-0.001552	0.001844	-0.841669	0.4005
DCO2EM	0.141978	0.035418	4.008606	0.0001
TFR	-0.123102	0.109197	-1.127340	0.2602
INTERNET	0.001484	0.001483	1.000691	0.3176
INFLCP	0.020028	0.010330	1.938928	0.0532
LCHEUSD	0.057682	0.039175	1.472422	0.1417
C	-0.104694	0.350925	-0.298337	0.7656
RESID01(-1)	0.880303	0.046580	18.89876	0.0000
RESID01(-2)	0.053403	0.045726	1.167899	**0.2435**

Table 8. White Test - Homoscedasticity

Dependent Variable: RESID01^2				
Method: Panel Least Squares				
Total panel (balanced) observations: 486				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LIFEEXPF	-1.670580	1.241184	-1.345957	**0.1789**
LIFEEXPF^2	0.010038	0.008001	1.254685	**0.2102**
C	70.63209	48.08834	1.468799	0.1425

Table 9. Correlation Matrix

	DUNEMP	LGDP	UPPERC	DCO2EM	TFR	INTERNET	INFLCP	LCHEUSD
DUNEMP	1.000000							
LGDP	0.072935	1.000000						
UPPERC	0.055101	0.183513	1.000000					
DCO2EM	-0.148306	-0.067222	-0.104436	1.000000				
TFR	0.104099	0.252117	0.317934	-0.086923	1.000000			
INTERNET	-0.040795	0.261837	0.389005	-0.182597	0.428833	1.000000		
INFLCP	0.018684	-0.197928	-0.207085	0.061683	-0.146789	-0.423009	1.000000	
LCHEUSD	0.166612	0.548807	0.527594	-0.180948	0.497228	0.640762	-0.396158	1.000000

Table 10. Correlation between residuals and regressors

	RESID01
DUNEMP	2.35E-15
LGDP	-2.64E-13
UPPERC	4.07E-14
DCO2EM	3.33E-15
TFR	1.79E-13
INTERNET	3.17E-14
INFLCP	8.80E-15
LCHEUSD	1.43E-13
Mean of Residuals	-4.88E-17

Table 11. Jarque-Bera Test

	RESID01
Jarque-Bera	0.901668
Probability	0.637097

3. RESULTS AND DISCUSSION

Based on the final estimation output derived from the implementation of a Fixed Effects Model, with fixed periods, all regressors are found to be highly significant apart from unemployment rate and carbon dioxide emission. To justify accordingly – Gross Domestic Product has a significant positive sign which is absolutely in reliance with literature (Poças et al. 2020). When GDP changes by 1 percent, we expect life expectancy to increase by 0.00105 units, Ceteris Paribus. H_1 hypothesis is satisfied. This can be explained by the fact that when people possess higher income, they are going to consume services and goods of high-quality and increase the life standard by improving their housing and selecting top-notch medical services.

Urban Population is found to be highly significant with a positive sign, which is still consistent with literature (Monsef and Mehrjardi 2015). When urban population changes by 1 percentage point, we expect life expectancy to increase by 0.019 units, Ceteris Paribus. H_3 hypothesis is satisfied. This can be supported through the fact that the nearer the people are to the urban areas, the more access to medical services they will have, which as a response is going to improve their health and increase life span.

Next, total fertility rate is found to be highly significant at all significance levels and contains a negative sign, again consistent with previous studies (Jafrin et al. 2021). When total fertility rate increases by 1 unit, life expectancy is expected to decrease by 2.203 units, Ceteris Paribus. H_3 hypothesis is satisfied too. In order to interpret such a result, we can stick to the classical evolutionary theory of aging which foresees a trade-off association between life expectancy and fertility. As lifespan tends to increase, this will come at the cost of reduced fertility because the population grows older and becomes less reproductive.

Afterwards, inflation has a negative significant sign, aligned with the study of Monsef and Mehrjardi (2015), which indicates a decrease of 0.148 units in life expectancy when inflation increases by 1 percentage point, Ceteris Paribus. The reason behind this lies in the fact that as the overall prices rise, the population's purchasing power parity decreases, their consumption lowers, medical issues arise and the overall life satisfaction worsens. H_7 hypothesis is satisfied.

Health expenditure is revealed to have a positive significant sign, consistent with literature (Azam et al. 2023). When spendings on health increase by 1 percent, life expectancy is expected to extend by 0.03538 units, Ceteris Paribus, which is already pretty logical to be related with the reasoning that as long as people invest on health issues and take care of themselves, they will tend to live healthier and longer. H_8 hypothesis is satisfied.

Next, the unemployment rate is found to be totally insignificant statistically speaking and this result is consistent with previous papers (Tafran et al. 2020). According to Eurostat, the unemployment rate has been decreasing in recent years in EU countries and this can be considered as a logical reason why the unemployment rate does not contribute in explaining changes in life expectancy. Following carbon dioxide emission, its impact is found to be totally insignificant as well (James et al. 2017) – thus, its interpretation is skipped. Such a finding is expected with regard to the European Union as it has implemented a wide range of policies to limit air pollution triggered by individual and national sources and it does have a clear vision towards tackling air pollution in the near future. H_2 and H_4 hypothesis are not satisfied.

Last but not least, internet usage is significant with a negative sign while we were expecting a positive one due to the integration of digital technology in these developed countries. When internet usage increases by 1 percentage point, life expectancy will be shortened by 0.062 units, Ceteris Paribus. H_6 hypothesis is fully satisfied. The study of Reinecke et al. (2016) is taken into consideration to support this finding. Internet usage has a significant and negative impact on health and psychological issues, which as a result decreases the overall life satisfaction and shortens life longevity.

Table 12. Final Estimation Output

Dependent Variable: LIFEEXP				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
DUNEMP	-0.016276	0.046830	-0.347560	**0.7283**
LGDP	0.105419	0.044411	2.373727	0.0180
UPPERC	0.019778	0.005471	3.615154	0.0003
DCO2EM	-0.131363	0.112518	-1.167487	**0.2436**
TFR	-2.203104	0.326747	-6.742548	0.0000
INTERNET	-0.062076	0.005820	-10.66617	0.0000
INFLCP	-0.148278	0.033046	-4.487068	0.0000
LCHEUSD	3.538570	0.122270	28.94059	0.0000
C	55.32289	1.037093	53.34420	0.0000
Effects Specification	Period fixed (dummy variables)			
R-squared	**0.859463**			
F-statistic	112.5261			
Prob(F-statistic)	**0.000000**			

4. CONCLUSION

This study examined over a long-time interval 2001-2021 a considerable number of independent variables in explaining life expectancy at birth such as unemployment rate, GDP, urban population, CO2 emission, total fertility rate, inflation, health expenditure and internet usage. All indicators were found to have a significant impact on life longevity except for unemployment rate and CO2 emission. This seems to be a highly positive aspect within the EU, as it indicates that job opportunities are encouraged and the governmental regulation framework is working hard on the improvement of air quality by reducing pollution – hence, we recommend the continuation of such effective strategies. The most crucial finding which needs great attention is the negative impact of internet usage on the life span of EU countries' population. Even though the internet highly contributes to life 's progress, the tremendous disadvantages that it brings out like stress, lack of sleep and mental issues must be taken into account urgently. We strongly suggest finding alternatives to technology, monitoring and limiting the use of the internet and of course, teaching conscious behavior and responsibility since childhood. Last but not least, the only limitation of this paper is the fact that some other vital indicators could have been included in order to improve the overall econometric equation for more precise results. Hygiene, mean years of schooling, crime rates, diet and nutrition, smoking

rate, alcohol usage and food habits are advised to be incorporated in further studies. In conclusion, this research paper could be useful to smart governments that want to estimate the overall health of a nation so that they maximize the wealth and wellness of the citizens. The healthier the population, the more successful the government will be in terms of electoral priorities and the enhancement of economic growth.

REFERENCES

[1] Ali A, Ahmad K. (2014). The Impact of Socio-Economic Factors on Life Expectancy in Sultanate of Oman: An Empirical Analysis. Middle-East Journal of Scientific Research. 2014; 22(2): 218-24.
[2] Audrey, L., 2004. Do economic cycles have a permanent effect on population health? Revisiting the Brener hypothesis. Health Economics 13, 767–779.
[3] Azam, M., Uddin, I., & Saqib, N. (2023). The determinants of life expectancy and environmental degradation in Pakistan: evidence from ARDL bounds test approach. Environmental Science and Pollution Research, 30(1), 2233-2246.
[4] Bayati M, Akbarian R, Kavosi Z. (2013). Determinants of life expectancy in eastern Mediterranean region: a health production function. Int J Health Policy Manag. 2013; 1(1): 57-61. doi: 10.15171/ijhpm.2013.09. PMID: 24596837, PMCID: PMC3937941
[5] Bergh, A. and T.H. Nilsson, 2009. Good for living? On the relation between globalization and life expectancy. World Development, 38(9): 1191-1203
[6] Bilas, V., Franc, S., & Bošnjak, M. (2014). Determinant factors of life expectancy at birth in the European Union countries. Collegium antropologicum, 38(1), 1-9.
[7] Blazquez-Fernández, C., Cantarero-Prieto, D., & Pascual-Saez, M. (2017). Health expenditure and socio-economic determinants of life expectancy in the OECD Asia/Pacific area countries. Applied Economics Letters, 24(3), 167-169.
[8] Christensen, K., Doblhammer, G., Rau, R., & Vaupel, J. (2009). Ageing populations: The challenges ahead. The Lancet, 374, 1196–1208.
[9] Delavari S., Zandian H., Rezaei S., Moradinazar M., Delavari S., Saber A., Fallah R., 2008. Life expectancy and its socioeconomic determinants in Iran, Electr. Phys., 2016, 8 (10), 3062–3068.
[10] Fayissa, B., Gutema, P., 2005. Estimating a health production function for sub-saharan Africa (SSA). Applied Economics 37, 155–164.
[11] Halicioglu, F. (2011). Modeling life expectancy in Turkey. Economic modelling, 28(5), 2075-2082.
[12] Hassan, F. A., Minato, N., Ishida, S., & Nor, N. M. (2017). Social environment determinants of life expectancy in developing countries: a panel data analysis. Global Journal of Health Science, 9(5), 105-117.
[13] Jafrin, N., Masud, M. M., Saif, A. N. M., Mahi, M., & Khanam, M. (2021). A panel data estimation of the determinants of life expectancy in selected SAARC countries. Oper Res Decis, 31.
[14] James, C., Devaux, M., & Sassi, F. (2017). Inclusive growth and health. OECD Health working papers, No. 103, OECD Publishing, Paris
[15] Kabir, M. (2008). Determinants of life expectancy in developing countries. The Journal of Developing Areas, 41(2), 185-204.
[16] Khuder, S.A., 2001. Effects of cigarette smoking on major histological types of lung cancer: a meta-analysis. Lung Cancer 31, 139–148
[17] Leung, M.C.M. and Y. Wang, 2003. Endogenous health care and life expectancy in a neoclassical growth model. Singapore: World Scientific Publishing Co.

[18] Lichtenberg, F.R., 2002. Sources of U.S. longevity increase, 1960–1997. NBER Working Paper, No.8755
[19] Mariani, F., P. Barahona and N. Raffin, 2008. Life expectancy and the environment. CES Working Papers, No. 48: 1-23.
[20] Miller Jr., R.D., Frech, H.E., 2000. Is there link between pharmaceutical consumption and improved health in OECD countries? Pharmacoeconomics 18, 33–45 (Supplement)
[21] Monsef, A., & Mehrjardi, A. S. (2015). Determinants of life expectancy: A panel data approach. Asian Economic and Financial Review, 5(11), 1251-1257.
[22] Nixon, J., Ulmann, P., 2006. The relationship between health care expenditure and health outcomes: evidence and caveats for a causal link. European Journal of Health Economics 7, 7–18
[23] Peltzman, S., 1987. Regulation and health: the case of mandatory prescriptions and an extension. Managerial and Decision Economics 8, 41–46
[24] Poças, A., Soukiazis, E., & Antunes, M. (2020). Factors Explaining Life Expectancy at Age 65: A Panel Data Approach Applied to European Union Countries. Social Indicators Research. doi:10.1007/s11205-020-02290-2
[25] Reinecke, L., Aufenanger, S., Beutel, M. E., Dreier, M., Quiring, O., Stark, B., … Müller, K. W. (2016). Digital Stress over the Life Span: The Effects of Communication Load and Internet Multitasking on Perceived Stress and Psychological Health Impairments in a German Probability Sample. Media Psychology, 20(1), 90–115.
[26] Shing-Jong, L., 2009. Economic fluctuations and health outcome: a panel analysis of Asia-Pacific countries. Applied Economics 41, 519–530
[27] Tafran, K., Tumin, M., & Osman, A. F. (2020). Poverty, income, and unemployment as determinants of life expectancy: Empirical evidence from panel data of thirteen Malaysian states. Iranian journal of public health, 49(2), 294.
[28] Thorton, J., 2002. Estimating a health production function for the US: some new evidence. Applied Economics 34, 59–62
[29] Yavari, K. and M. Mehrnoosh, 2006. Determinants of life expectancy: A cross – country. Iranian Economic Review, 11(15): 13-142.
[30] Zaidi, A. (2014). Life cycle transitions and vulnerabilities in old age: A review. Human Development Report

Ethics in AI, XR and Digitalization: A Systematic Literature Review

Osman Koroglu[1]*

[1]*Department of Business Administration, Faculty of Economics and Administrative Sciences, EPOKA University, Autostrada Tiranë-Rinas, Km. 12, 1032, Tirana, Albania*
** Corresponding author: okoroglu@epoka.edu.al;*

Abstract

As AI, XR, and digitalization increasingly pervade our daily lives, it is crucial to address their ethical implications. This paper provides a systematic literature review of the topic to offer an overview of the current state of research. Through rigorous analysis, we identified key ethical concerns related to these technologies, such as accountability, transparency, privacy, security, and bias. Additionally, we examined the ethical implications of digitalization, including the potential for job displacement, cyber threats, and the ethical considerations of algorithmic decision-making. Our findings highlight the need for further research into the ethical implications of AI and digitalization, particularly in marketing. Future research could explore issues related to privacy, security, bias, and responsible use of these technologies. Ultimately, this paper offers valuable insights for researchers, practitioners, and policymakers seeking to understand and address the ethical challenges of AI, XR, and digitalization.

Keywords: *Ethics, AI, XR, Digitalization, Systematic Literature Review.*

1. INTRODUCTION

As technology continues to advance, ethical concerns surrounding AI, XR, and digitalization have become increasingly prevalent [1]. Autonomous systems are already in use in critical social institutions, but there are no universally accepted methods to evaluate their long-term effects on people [2]. This paper presents a systematic literature review of the ethical implications of these technologies. The review identifies key ethical concerns, such as accountability [3], transparency [4], privacy, security [1], and bias [5], and explores the ethical implications of digitalization, including potential job displacement [6]; [4], cyber threats, and algorithmic decision-making [5]. By providing an overview of the current state of research on the ethical implications of these technologies, this paper offers valuable insights for researchers, practitioners, and policymakers. The findings underscore the importance of continued research into the ethical implications of AI and digitalization, especially within the realm of marketing [7]. Many proposals published to address ethical issues related to artificial intelligence (AI) are too abstract [8]. They also highlight the need for proactive measures to ensure responsible and ethical use of these technologies.

2. METHODS

For this paper, a systematic literature review methodology was employed to identify and analyze relevant studies on the ethical implications of AI, XR, and digitalization. Inclusion criteria were based on relevance to the topic, citation number, and recency, with only references published since 2013 being considered. Exclusion criteria were based on relevance and subjective originality. A preliminary review article search on Google Scholar database using the keywords "AI, ethics", "XR, ethics", and "digitalization, ethics" resulted in a total of 39,390 items. These results were refined using the Publish or Perish Software [9] to ensure that only items meeting the inclusion criteria were considered and all of them added as references. In addition to academic references, data from experts and respected organizations were also included in the study.

3. ETHICS IN AI

The rapid advancement of artificial intelligence (AI) has raised ethical concerns that must be addressed [10]; [11]. AI is defined as the development of intelligent machines that can perform tasks requiring human intelligence, with applications in healthcare, finance, transportation, education, and entertainment. Despite its benefits, AI presents ethical challenges [12], including fairness [13], bias, accountability, transparency, and privacy. Biases can be perpetuated and amplified by AI systems [14], while determining responsibility for AI actions can become increasingly complex. Lack of transparency and collection of personal data also present ethical concerns [15]. Scholars and practitioners are actively developing ethical frameworks and evaluation tools for AI [16], but more work is needed to ensure that ethical principles such as non-maleficence [17] are aligned with AI development and deployment.

4. ETHICS IN XR

Extended Reality (XR) is a technology that merges the physical and virtual worlds, offering immersive experiences for gaming, education, healthcare, and entertainment [18]. XR encompasses Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR). While XR has numerous benefits [19], it also presents ethical challenges [20]. These include impact on user perception of reality [21], potential for addiction [22], and ethical concerns around data collection [23]; [24]; [25]. XR can blur the lines between reality and the virtual world [26], leading to confusion, disorientation, and psychological harm [27]. XR experiences can be highly engaging, leading to addiction and negative outcomes, especially for vulnerable populations [28]. XR data collection raises concerns about privacy, security, surveillance, and discrimination [29]. Although scholars and practitioners are working on ethical frameworks, tools, and techniques to address these challenges, much work remains to ensure ethical alignment of XR's development and deployment [30]; [31].

5. ETHICS IN DIGITALIZATION

Business digitalization refers to the process of using digital technologies to transform business operations, processes, and models. It involves the integration of digital technologies into all areas of a business, including customer interactions, supply chain management, and employee productivity [32]; [33]. Digitalization also refers to the process of transforming analog data into digital form using digital technologies. Businesses are driven by competition for their digitalization efforts [34]. It has impacted various sectors of the economy, including healthcare [35], education, and manufacturing. For instance, in the healthcare sector, digitalization has led to the development of telemedicine, which has improved access to

medical care for people in remote areas [36]. While digitalization has brought many benefits, it has also presented ethical challenges [37] such as job loss [38], cyber threats (cybercrimes, identity theft, financial fraud, cyberbullying), and algorithmic decision-making concerns [39]. The use of algorithms to make decisions in areas such as credit scoring, job hiring, and criminal justice has raised concerns about bias and discrimination [40]. The lack of transparency and accountability in algorithmic decision-making has made it difficult to address these concerns [41]. Research on ethics in digitalization is still in the early stages, and interdisciplinary collaboration between scholars in various fields -including computer science, philosophy, sociology, and law [42]- is needed to address these challenges [43].

6. FINDINGS AND DISCUSSION

Ethical frameworks, transparency, and accountability are necessary to guide the development and use of AI, XR, and digitalization technologies. The literature highlights the need for responsible governance, addressing bias and discrimination, and considering potential job loss and impacts on privacy and security [44]. However, there are distinct ethical challenges in each area and there are both radical voices saying the focus should be on systems of oppression and others discussing about options [45]; [46]. The AI literature raises concerns about bias and discrimination in algorithmic decision-making, while the XR literature focuses on privacy and security issues in immersive technologies. Digitalization literature raises concerns about job loss and economic inequality. Limitations include a lack of empirical research and diversity in scholarship. Our research suggests that AI and XR will merge to become AIXR [47]; [48]. Researchers must consider this and should conduct more empirical research [49] and develop ethical frameworks and guidelines. Practitioners should prioritize transparency and accountability and identify potential risks and harms [50]. Policymakers should develop regulations and policies based on evidence-based research and consultation with stakeholders [51]. Future research should focus on developing ethical frameworks for specific contexts and addressing bias and discrimination in algorithmic decision-making [52].

7. CONCLUSION

This systematic literature review has provided an overview of the ethical implications of AI, XR, and digitalization. These are the main ethical research issues in the literature reviewed: [AI] Bias and Fairness: AI systems can reflect the biases of their creators and the data used to train them, leading to unfair or discriminatory outcomes. Privacy and Surveillance: AI technologies can be used to collect and analyze vast amounts of personal data, leading to concerns about surveillance, tracking, and intrusion. Accountability and Transparency: AI systems can be difficult to understand and hold accountable, which can create challenges for transparency, oversight, and responsibility. Autonomous Decision-Making: AI systems can make decisions without human intervention, raising questions about who is responsible for their actions and how they can be held accountable. [XR] Virtual Harassment and Bullying: XR technologies can be used to harass or bully individuals in virtual spaces, creating harm that can be difficult to escape. Addiction and Dependency: XR technologies can be highly engaging and immersive, leading to concerns about addiction and dependency. Privacy and Surveillance: XR technologies can collect and transmit personal data, leading to concerns about surveillance, tracking, and intrusion. Access and Inclusion: XR technologies can create new forms of exclusion and marginalization, especially for those who do not have access to the necessary

technology. [Digitalization] Worker Displacement: Digitalization can automate or replace jobs, leading to concerns about unemployment and economic inequality. Data Privacy and Security: Digitalization can involve collecting and processing large amounts of personal data, leading to concerns about privacy and security. Corporate Responsibility: Digitalization can create new opportunities for corporate power and influence, raising questions about responsibility and accountability. Environmental Impact: Digitalization can have significant environmental impacts, such as increased energy consumption and e-waste.

The findings underscore the need for further research into the ethical implications of AI, XR and digitalization. This paper has contributed to ongoing discussions and debates about the ethical considerations, providing a foundation for future research and policy decisions. It has highlighted the importance of proactive measures to ensure responsible and ethical use of these technologies and the need for ethical principles to be aligned with their development and deployment. Scholars and practitioners are actively developing ethical frameworks and evaluation tools for these technologies, but more work is needed to ensure that ethical principles are aligned with their development and deployment. The insights provided in this paper are valuable for researchers, practitioners, and policymakers seeking to understand and address the ethical challenges posed by these technologies.

REFERENCES

[1] IEEE SA. (2022). Ethical Considerations of Extended Reality (XR). IEEE SA. standards.ieee.org/beyond-standards/industry/technology-industry/ethical-considerations-of-extended-reality-xr

[2] Crawford, K., & Calo, R. (2016). There is a blind spot in AI research. *Nature News*, 538(7625), 311.

[3] Radu, G. (2023) The Ethical Implications of AI in Business Digitalization. *LinkedIn*. linkedin.com/pulse/ethical-implications-ai-business-digitalization-george-radu

[4] Deloitte Insights. (2023, March 18). Ethics and the future of work. www2.deloitte.com/us/en/insights/focus/human-capital-trends/2020/ethical-implications-of-ai.html

[5] Pazzanese, C. (2020). Great promise but potential for peril. *Harvard Gazette*. news.harvard.edu/gazette/story/2020/10/ethical-concerns-mount-as-ai-takes-bigger-decision-making-role

[6] Davenport, T. H., & Ronanki, R. (2018). Artificial intelligence for the real world. *Harvard Business Review*, 96(1), 108-116.

[7] Hutchinson, E. (2022). The Role Of Ethics In The Evolving World Of Marketing AI. *Forbes*. forbes.com/sites/forbescommunicationscouncil/2022/08/17/the-role-of-ethics-in-the-evolving-world-of-marketing-ai/?sh=67488b112e97

[8] Prem, E. (2023). From ethical AI frameworks to tools: a review of approaches. *AI Ethics*, 1–18. doi.org/10.1007/s43681-023-00258-9

[9] Harzing, A.W. (2007) Publish or Perish, harzing.com/resources/publish-or-perish

[10] UNESCO. (2021). Ethics of Artificial Intelligence. UNESCO. unesco.org/en/artificial-intelligence/recommendation-ethics

[11] Broderick, T., Gelman, A., Meager, R., Smith, A. L., & Zheng, T. (2023). Toward a taxonomy of trust for probabilistic machine learning. *Scientific Advances.*, 9(7), eabn3999. doi: 10.1126/sciadv.abn3999

[12] Khan, A. A., Badshah, S., Liang, P., Khan, B., Waseem, M., Niazi, M., & Akbar, M. A. (2021). Ethics of AI: A Systematic Literature Review of Principles and Challenges. *arXiv*. arxiv.org/abs/2109.07906v1

[13] Xivuri, K., & Twinomurinzi, H. (2021). A systematic review of fairness in artificial intelligence algorithms. In Responsible AI and Analytics for an Ethical and Inclusive Digitized Society: 20th IFIP WG 6.11 *Conference on e-Business, e-Services and e-Society*, I3E 2021, Galway, Ireland, September 1–3, 2021, Proceedings 20 (pp. 271-284). Springer International Publishing.

[14] Blackman, R. (2020). A Practical Guide to Building Ethical AI. *Harvard Business Review*. hbr.org/2020/10/a-practical-guide-to-building-ethical-ai

[15] Australian Government. (2019). Australia's Artificial Intelligence Ethics Framework. Department of Industry, Science and Resources. industry.gov.au/publications/australias-artificial-intelligence-ethics-framework

[16] Director of National Intelligence. (2020). INTEL - Artificial Intelligence Ethics Framework for the Intelligence Community. intelligence.gov/artificial-intelligence-ethics-framework-for-the-intelligence-community

[17] Laine, J. (2021). Ethics-based AI auditing core drivers and dimensions: A systematic literature review (Dissertation). utupub.fi/handle/10024/152795

[18] Hirzle, T., Müller, F., Draxler, F., Schmitz, M., Knierim, P., & Hornbæk, K. (2023, April). When XR and AI Meet - A Scoping Review on Extended Reality and Artificial Intelligence. In Proceedings of the *2023 CHI Conference on Human Factors in Computing Systems (CHI '23)*.

[19] Alam, A., & Mohanty, A. (2022). Metaverse and Posthuman Animated Avatars for Teaching-Learning Process: Interperception in Virtual Universe for Educational Transformation. In *International Conference on Innovations in Intelligent Computing and Communications* (pp. 47-61). Springer, Cham.

[20] Morrow, M. (2023). Extended Reality and Ethics: Coexistence in the Modern Era. *LinkedIn*. linkedin.com/pulse/extended-reality-ethics-coexistence-modern-era-monique-morrow/

[21] Rauschnabel, P. A., Felix, R., Hinsch, C., Shahab, H., & Alt, F. (2022). What is XR? Towards a framework for augmented and virtual reality. *Computers in Human Behavior*, 133, 107289.

[22] Qamar, S., Anwar, Z., & Afzal, M. (2023). A systematic threat analysis and defense strategies for the metaverse and extended reality systems. *Computers & Security*, 103127.

[23] Evans, J. (2022). White Paper-The IEEE Global Initiative on Ethics of Extended Reality (XR) Report--Extended Reality (XR) Ethics in Medicine.

[24] IEEE SA. (2020). The IEEE global initiative on ethics of extended reality. standards.ieee.org/industry-connections/ethics-extended-reality/

[25] Smith, C. H., Molka-Danielsen, J., Rasool, J., Webb-Benjamin, J. B., & UK, K. L. (2023, January). The World as an Interface: Exploring the Ethical Challenges of the Emerging Metaverse. In Proc. *Hawaii International Conference of System Sciences* (pp. 6045-6054).

[26] Pamparău, C., Schipor, O. A., Dancu, A., & Vatavu, R. D. (2023). SAPIENS in XR: operationalizing interaction-attention in extended reality. *Virtual Reality*, 1-17.

[27] Miah, A. (2023). The Moral Metaverse: Establishing an Ethical Foundation for XR Design. In *Understanding Virtual Reality* (pp. 112-128). Routledge.

[28] Margrett, J. A., Ouverson, K. M., Gilbert, S. B., Phillips, L. A., & Charness, N. (2022). Older Adults' Use of Extended Reality: A Systematic Review. *Frontiers in Virtual Reality*, 2, 176.

[29] Abraham, M., Saeghe, P., Mcgill, M., & Khamis, M. (2022, October). Implications of XR on Privacy, Security and Behaviour: Insights from Experts. In *Nordic Human-Computer Interaction Conference* (pp. 1-12).

[30] Mangina, E. (2021). The IEEE Global Initiative on Ethics of Extended Reality (XR) Report--Extended Reality (XR) Ethics in Education. pp.1-27, https://ieeexplore.ieee.org/document/9650798

[31] Lee, J. J., & Hu-Au, E. (2021). E3XR: An Analytical Framework for Ethical, Educational and Eudaimonic XR Design. *Frontiers in Virtual Reality.*, 2. doi: 10.3389/frvir.2021.697667

[32] Ritter, T., & Pedersen, C. L. (2020). Digitization capability and the digitalization of business models in business-to-business firms: Past, present, and future. *Industrial Marketing Management*, 86, 180–190. doi.org/10.1016/j.indmarman.2019.11.019

[33] Reis, J., Amorim, M., Melão, N., Cohen, Y., & Rodrigues, M. (2020). Digitalization: A literature review and research agenda. In Proceedings on *25th International Joint Conference on Industrial Engineering and Operations Management–IJCIEOM: The Next Generation of Production and Service Systems* 25 (pp. 443-456). Springer International Publishing.

[34] Bughin, J., Manyika, J., & Catlin, T. (2019). Twenty-five years of digitization: Ten insights into how to play it right. *McKinsey & Company*. mckinsey.com/capabilities/mckinsey-digital/our-insights/twenty-five-years-of-digitization-ten-insights-into-how-to-play-it-right

[35] Kargl, M., Plass, M., & Müller, H. (2022). A literature review on ethics for ai in biomedical research and biobanking. *Yearbook of Medical Informatics*, 31(01), 152–160. doi.org/10.1055/s-0042-1742516

[36] PricewaterhouseCoopers (2020). Digital ethics necessary for successful digital transformation. pwc.nl/en/topics/blogs/digital-ethics-necessary-for-successful-digital-transformation.html

[37] Nabbosa, V., & Kaar, C. (2020). Societal and Ethical Issues of Digitalization. ICBDM 2020: Proceedings of the 2020 International Conference on Big Data in Management. *Association for Computing Machinery*. doi.org/10.1145/3437075.3437093

[38] Balsmeier, B., & Woerter, M. (2019). Is this time different? How digitalization influences job creation and destruction. *Research policy*, 48(8), 103765.

[39] Brynjolfsson, E., & Mitchell, T. (2017). What can machine learning do? Workforce implications. *Science*, 358(6370), 1530-1534.

[40] Gromova K., Eferin Y. (2021). Ethics in the digital world: Where we are now and what's next. *World Bank Group Data Blog*. blogs.worldbank.org/opendata/ethics-digital-world-where-we-are-now-and-whats-next

[41] Berkman Klein Center for Internet & Society at Harvard University. (2021). The Ethics of Digitalization. Berkman Klein Center. cyber.harvard.edu/projects/ethics-digitalization

[42] Khan, A. A., Akbar, M. A., Fahmideh, M., Liang, P., Waseem, M., Ahmad, A., Niazi, M., & Abrahamsson, P. (2022). Ai ethics: An empirical study on the views of practitioners and lawmakers. doi.org/10.48550/ARXIV.2207.01493

[43] Capurro, R. (2017). Digitization as an ethical challenge. *Ai & Society*, 32(2), 277-283.

[44] Woodgate, J., & Ajmeri, N. (2022). Principles for Macro Ethics of Sociotechnical Systems: Taxonomy and Future Directions. *arXiv*, 2208.12616. arxiv.org/abs/2208.12616v1

[45] Munn, L. (2022). The uselessness of AI ethics. *AI and Ethics*. semanticscholar.org/paper/The-uselessness-of-AI-ethics-Munn/0ea5edaae43b26798190fd6ead50d447033e7d13

[46] Lundgren, B. (2023). In defense of ethical guidelines. *AI Ethics*, 1–8. doi.org/10.1007/s43681-022-00244-7

[47] Koroglu, O. (2023). AI and XR (AIXR) marketing in Industry 5.0 or Society 5.0. In B. Akkaya, E. Hysa, M. Panait, & S. Apostu (Eds.), *Digitalization, Sustainable Development, and Industry 5.0: An Organizational Model for Twin Transitions*. Emerald Publishing.

[48] Koroglu, O. (2023). Can AIXR (AI and XR) enhance communication and happiness? *4th International Scientific Conference* "Happiness And Contemporary Society", The Ukrainian Institute for Happiness Research.

[49] Ryan, M., Antoniou, J., Brooks, L., Jiya, T., Macnish, K., & Stahl, B. (2021). Research and practice of AI ethics: a case study approach juxtaposing academic discourse with organisational reality. *Science and Engineering Ethics*, *27*, 1-29.

[50] White, J. M., & Lidskog, R. (2022). Ignorance and the regulation of artificial intelligence. *Journal of risk research*, *25*(4), 488-500.

[51] Patel, J., Manetti, M., Mendelsohn, M., Mills, S., Felden, F., Littig, L., & Rocha, M. (2022). AI Brings Science to the Art of Policymaking. BCG Global. bcg.com/publications/2021/how-artificial-intelligence-can-shape-policy-making

[52] Kordzadeh, N., & Ghasemaghaei, M. (2022). Algorithmic bias: review, synthesis, and future research directions. *European Journal of Information Systems*, *31*(3), 388-409.

The Intersection of Gender and the Economy: Understanding Gender Gaps and How to Address Them; The Case of Albania

Arjela Dervishaj[1]*, Mirela Alhasani (Dubali)[2]*

[1]*Department of Business Administration, Faculty of Economics and Administrative Sciences, EPOKA University, Autostrada Tiranë-Rinas, km. 12, 1032, Tirana, Albania*
[2]*Center for European Studies, Faculty of Law and Social Sciences, EPOKA University, Autostrada Tiranë-Rinas, km. 12, 1032, Tirana, Albania*
Corresponding author: adervishaj19@epoka.edu.al; malhasani@epoka.edu.al;

Abstract

This paper examines the intersection of gender and the economy in Albania, focusing on understanding gender gaps and strategies to address them. It begins by providing an overview of the current state of gender equality in Albania, highlighting both progress made and persistent challenges. The paper then delves into the economic dimension of gender inequality, exploring the gender pay gap, labor force participation, and entrepreneurship. Through a review of existing literature gathered through academic sources and analysis of data from various sources including the Albanian Institute of Statistics, the OECD, and the World Bank, the paper identifies key factors contributing to gender gaps in the economy, including cultural norms, limited access to finance and training, and discriminatory practices. Finally, the paper considers potential solutions to address gender gaps in the economy, drawing on examples from Albania and beyond. Recommendations include increasing access to finance and training for women, promoting flexible work arrangements, and implementing gender-responsive budgeting. Overall, this paper provides insights into the complex and multifaceted nature of gender inequality in the economy and offers strategies to promote greater gender equality and economic empowerment in Albania.

Keywords: *gender gaps, gender equality, economy, Albania.*

1. INTRODUCTION

Gender inequality remains a persistent challenge in many countries around the world, and Albania is no exception. Despite progress in recent years, significant gender gaps persist in Albania's economy, particularly in terms of labor force participation, wages, and occupational segregation. These gaps not only have negative impacts on women's economic outcomes and well-being but also represent a substantial economic cost to the country, through lost productivity and growth.

This study aims to contribute to our understanding of the intersection of gender and the economy in Albania, with a specific focus on understanding the nature and causes of gender gaps in the country's labor market and identifying effective policy interventions for reducing these gaps and promoting greater gender equality. The study will adopt a mixed-methods approach, combining quantitative analysis of secondary data sources, such as official statistics and data from international organizations, with qualitative

analysis of primary data sources collected through Google Forms and analysis of patterns and themes derived from the literature review.

The study will contribute to a growing body of research on the intersection of gender and the economy and will provide valuable insights for policymakers, employers, and other stakeholders in Albania and beyond who are working to promote greater gender equality and economic development.

1.1 Background information

Gender inequality in the economy has been a persistent issue across countries and regions, with women consistently facing a range of barriers to equal participation in the workforce and economic opportunities. This has negative impacts not only on women themselves but also on the overall economy, as research has shown that reducing gender gaps can lead to higher economic growth and productivity [1]. The case of Albania is particularly relevant in this context, as the country has undergone significant economic and social transformations over the past few decades, following the collapse of communism in the early 1990s. While Albania has made progress in a few areas, such as increasing overall GDP and reducing poverty rates, gender gaps in the economy remain significant [2].

According to the World Economic Forum's Global Gender Gap Report 2021, Albania ranks 56th out of 156 countries in terms of gender equality, with a score of 0.738 (out of 1.0) [3]. While this is an improvement from previous years, there are still notable gender gaps in several areas, such as labor force participation, where women's rate is 47.9% compared to men's 65.7%, wage equality, women earn 71.6% of what men earn for similar work, and women's representation in leadership positions[3]. The causes of these gender gaps are complex and multifaceted, with factors such as patriarchal social norms, discrimination, lack of access to education and training, and inadequate policies and legal frameworks all playing a role [2;4].

The aim of this research is to deepen our understanding of gender gaps in the Albanian economy, as well as to identify effective policy interventions that can help reduce these gaps and promote greater gender equality. By examining the specific case of Albania, we can shed light on the challenges and opportunities that arise in the context of a country undergoing economic and social transitions and draw lessons that may be relevant for other countries facing similar issues.

1.2 Research Questions

The overarching aim of this research is to investigate the intersection of gender and the economy in Albania, with a particular focus on understanding the nature and causes of gender gaps in the country's labor market, and identifying policy interventions that can help reduce these gaps and promote greater gender equality. In order to achieve this aim, the following research questions have been developed:

Research Questions:

1. What are the key gender gaps in Albania's labor market, and how do they vary across different sectors, occupations, and demographic groups?
2. What are the economic costs of gender gaps in Albania, and how do they affect the country's overall productivity, competitiveness, and growth potential?
3. What are the most promising and effective policy interventions for reducing gender gaps in Albania's economy, and how can they be tailored to the specific needs and challenges of different sectors and regions of the country?

By addressing these research questions, this study aims to contribute to a better understanding of the intersection of gender and the economy in Albania, as well as to inform policy and practice in the country and beyond.

1.3 Overview of Methodology and Data Sources

This article is based on a review of existing literature on gender and the economy in Albania, as well as an analysis of available data from a range of sources. Data sources include national statistics, academic studies, and reports from international organizations such as the World Bank, the United Nations, and the Albanian Institute of Statistics.

The research study also utilized an online questionnaire as a method of data collection, with a sample size consisting of 30 participants who responded to the survey in a voluntary, anonymous, and self-administered manner. A mixed-method approach will be used, combining quantitative analysis of numerical data obtained from secondary sources and a thematic analysis of relevant literature to identify patterns and themes [5].

The use of both quantitative and qualitative methods, as well as a variety of data sources, will enable a comprehensive and nuanced understanding of the intersection of gender and the economy in Albania and will provide valuable insights into the nature and causes of gender gaps in the country's labor market, as well as the most effective policy interventions for reducing these gaps and promoting greater gender equality.

2. LITERATURE REVIEW

2.1 Gender gaps in Albania's economy

Albania has made significant progress in recent years in promoting gender equality, but gender gaps in the labor market remain a significant challenge. According to official statistics, the labor force participation rate for women in Albania was 51.5% in 2019, compared to 69.4% for men [6]. This represents a significant gender gap, and is partly driven by social norms and expectations that prioritize women's roles as caregivers and homemakers [7].

Women in Albania also face significant wage disparities, with the gender pay gap estimated at around 8% in 2018 [8]. This gap is driven by a range of factors, including occupational segregation, where women are concentrated in lower-paid and less-skilled jobs, and discrimination, where women are paid less than men for performing the same work [8]. Additionally, women are underrepresented in leadership and decision-making positions, both in the public and private sectors, further contributing to their lower pay and limited career advancement opportunities [9].

Occupational segregation is also a significant issue in Albania, with women more likely to work in certain sectors, such as education and health, and less likely to work in male-dominated sectors, such as construction and engineering [8]. This reflects broader social norms and stereotypes about gender roles and capabilities, as well as limited access to education and training opportunities for women [7].

The causes of gender gaps in Albania's labor market are complex and multifaceted and are influenced by a range of social, cultural, and institutional factors. These include social norms and expectations about gender roles, discrimination, and biases in hiring and promotion, limited access to

education and training opportunities for women, and policy barriers, such as inadequate maternity and parental leave policies and limited access to affordable childcare [8].

Addressing gender gaps in Albania's labor market will require a comprehensive and multifaceted approach that addresses the underlying causes of these gaps and promotes greater gender equality across all sectors of the economy. This may include policy interventions such as promoting flexible work arrangements, improving access to education and training, and implementing gender-responsive budgeting and planning processes [9].

3. THE IMPACT OF GENDER GAPS ON ALBANIA'S ECONOMY

The gender gaps in Albania's labor market have significant economic costs, and can negatively impact the country's productivity, economic growth, and competitiveness.

3.1 Overview of the economic costs of gender gaps in Albania

Gender gaps in Albania's labor market lead to reduced participation and productivity of women, resulting in a loss of human capital that could otherwise contribute to economic growth Women's under-representation in leadership positions and in high-paying occupations also limits the country's capacity to leverage diverse perspectives and skills in decision-making, ultimately hindering innovation and economic development [11].

3.2 Analysis of the relationship between gender gaps and macroeconomic indicators

Gender gaps in Albania have been found to have a negative impact on macroeconomic indicators, including productivity, economic growth, and competitiveness. Studies have shown that closing gender gaps in education and labor market participation could increase Albania's GDP by up to 16% [8]. Furthermore, increasing women's access to finance and markets could boost the country's productivity and competitiveness [11]. Gender diversity in leadership and management roles has also been linked to improved economic performance and competitiveness [10].

Overall, addressing gender gaps in Albania's labor market is not only a matter of fairness and social justice but also an important economic imperative for the country's long-term growth and prosperity.

Table 1. Gender gaps within industries in Albania, 2020

Industry	Men's average monthly wage (ALL)	Women's average monthly wage (ALL)	Gender wage gap (%)
Agriculture, forestry, and fishing	43,120	36,485	15
Mining and quarrying	82,480	56,325	32
Manufacturing	62,742	47,580	24
Electricity, gas, and water supply	76,254	58,374	23
Construction	50,420	37,698	25
Wholesale and retail trade	46,285	33,982	26
Transportation and storage	68,940	52,635	24
Accommodation and food service	28,160	23,846	15

Information and communication	74,254	58,825	21
Financial and insurance activities	97,825	80,624	18
Real estate activities	51,742	42,936	17
Professional, scientific, and technical activities	76,568	61,672	19
Administrative and support service activities	41,285	34,672	16
Public administration and defense; compulsory social security	78,924	62,580	21
Education	63,385	53,284	16
Human health and social work	42,754	34,586	19
Arts, entertainment, and recreation	21,240	17,845	16
Other service activities	33,480	28,350	15

Source: Based on data from the Albanian Institute of Statistics [6].

Figure 1. Distribution of employed women by occupation in 2020, Albania

Table 1 presents data on gender gaps within industries in Albania in 2020, based on the average monthly wages of men and women in each industry. The data indicates that there are variations in the gender wage gap across industries. The largest gender wage gap was observed in the mining and quarrying industry (32%), followed by construction (25%), and wholesale and retail trade (26%). The smallest gender wage gaps were observed in agriculture, forestry, and fishing (15%), and accommodation and food service (15%).

These findings suggest that certain industries in Albania are more prone to gender wage gaps than others. Policies and programs to address these gaps should be tailored to the specific needs of each industry. Efforts to reduce occupational segregation and promote equal pay for equal work could help to reduce gender gaps within industries.

The evidence above indicates that a large share of employed women are concentrated in the services sectors which are usually characterized by low pay, long working hours, seasonality, and oftentimes informal working arrangements. It is important though to provide evidence of what positions women hold within these sectors. However, detailed data on employment by sectors and occupation are not available. The figure above shows the distribution of employed women by broad groups of occupations classified using ISCO-08.

The 2020 data for Western Balkan economies show that the category of managerial jobs is the smallest category, with just 1.1% of women being employed in this occupational category in.

Albania has the lowest share of women in the public sector and a lower percentage of women in the category of professionals. In addition, given that agriculture employs the highest share of women in Albania it has the highest share of women in the category of skilled agriculture [12].

3.3 Results of the online questionnaire

Table 2. Overview of the results of the online questionnaire

What is your gender?	What is your age?	What is your current occupation?	Have you ever experienced gender discrimination in your workplace?	In your opinion, how would you rate the level of gender equality in Albania's labor market?	What do you think are the main causes of gender gaps in Albania's economy? Please select all that apply.	What policies or programs do you think could be effective in reducing gender gaps in Albania's economy? Please select all that apply.	How important do you think it is to address gender gaps in Albania's economy?	Have you heard of any specific policies or programs aimed at reducing gender gaps in Albania's economy?	If you answered "yes" to the previous question, please specify the policies or programs you are aware of. If you answered "no" or "not sure," please skip this question.	Do you have any additional comments or suggestions on the topic of gender gaps in Albania's economy?
Female	18-24	Employed	No	3	a. Social norms, b. Discrimination, e. Lack of affordable childcare options	a. Equal pay legislation, d. Government subsidies for women-owned businesses, e. Affordable childcare options	5	No		No
Female	18-24	Employed	No	2	b. Discrimination	d. Government subsidies for women-owned businesses	3	No		Nope, crystal clear
Female	18-24	Employed	Not sure	2	a. Social norms, c. Lack of education and skills training, d. Limited access to credit and finance, e. Lack of affordable childcare options	a. Equal pay legislation, c. Education and skills training programs for women, e. Affordable childcare options	4	Not sure		No
Female	18-24	Employed	No	2	a. Social norms, b. Discrimination, c. Lack of education and skills training	a. Equal pay legislation, b. Affirmative action policies, d. Government subsidies for women-owned businesses, e. Affordable childcare options	5	Not sure		No
Female	18-24	Student	No	2	d. Limited access to credit and finance	c. Education and skills training programs for women	3	No		No i don't have
Female	18-24	Employed	No	3	b. Discrimination, c. Lack of education and skills training	b. Affirmative action policies, c. Education and skills training programs for women	5	No		no
Female	35-44	Employed	No	3	b. Discrimination	c. Education and skills training programs for women	3	No		No
Female	18-24	Student	Not sure	3	a. Social norms, d. Limited access to credit and finance, f. Lack of government policies to address gender gaps	a. Equal pay legislation, d. Government subsidies for women-owned businesses, e. Affordable childcare options	5	No		Nope
Female	18-24	Employed	Not sure	2	a. Social norms, c. Lack of education and skills training, d. Limited access to credit and finance	a. Equal pay legislation, b. Affirmative action policies, d. Government subsidies for women-owned businesses	5	No		No
Female	25-34	Employed	Not sure	3	a. Social norms, b. Discrimination, e. Lack of affordable childcare options	a. Equal pay legislation, b. Affirmative action policies, c. Education and skills training programs for women, d. Government subsidies for women-owned businesses, e. Affordable childcare options	5	Not sure		No
Prefer not to say	55 or above	Employed	Not sure	3	d. Limited access to credit and finance	c. Education and skills training programs for women	3	No		No
Male	35-44	Employed	No	3	a. Social norms	a. Equal pay legislation, b. Affirmative action policies, e. Affordable childcare options	4	Not sure		no
Female	18-24	Employed	Not sure	3	a. Social norms, e. Lack of affordable childcare options, f. Lack of government policies to address gender gaps	a. Equal pay legislation, b. Affirmative action policies, d. Government subsidies for women-owned businesses	5	No		No thank you
Female	25-34	Employed	No	4	c. Lack of education and skills training	b. Affirmative action policies	5	Not sure		No
Male	18-24	Employed	No	2	a. Social norms, b. Discrimination, e. Lack of affordable childcare options	c. Education and skills training programs for women, d. Government subsidies for women-owned businesses, e. Affordable childcare options	5	No		Nope
Female	25-34	Employed	No	4	a. Social norms, b. Discrimination, c. Lack of education and skills training, d. Limited access to credit and finance, e. Lack of affordable childcare options	a. Equal pay legislation, c. Education and skills training programs for women, e. Affordable childcare options	4	Not sure		More educations for women
Female	18-24	Employed	No	3	a. Social norms, e. Lack of education and skills training, f. Lack of government policies to address gender gaps	a. Equal pay legislation, b. Affirmative action policies, e. Affordable childcare options	5	No		I put 3 on the question - How would you rate gender equality in the labor market in Albania? -
Female	18-24	Student	No	3	d. Limited access to credit and finance	b. Affirmative action policies	3	No		No i dont have
Female	18-24	Student	Yes	2	a. Social norms, b. Discrimination, c. Lack of education and skills training, f. Lack of government policies to address gender gaps	a. Equal pay legislation, b. Affirmative action policies, c. Education and skills training programs for women, d. Government subsidies for women-owned businesses	5	No		men are trash
Female	35-44	Self-employed	Yes	1	a. Social norms, b. Discrimination, e. Lack of affordable childcare options, f. Lack of government policies to address gender gaps	b. Affirmative action policies, e. Affordable childcare options, It is an urgent need to make sure that future generations get educated on equality.	5	No		- Childcare options are really important for women to get back to work. It would be helpful if
Female	18-24	Employed	No	3	a. Social norms	b. Affirmative action policies,	5	No		No
Female	18-24	Student	No	3	c. Lack of education and skills training, f. Lack of government policies to address gender gaps	a. Equal pay legislation, d. Government subsidies for women-owned businesses	5	Not sure		No i dont have
Female	35-44	Self-employed	Yes	2	a. Social norms, b. Discrimination, c. Lack of education and skills training, d. Limited access to credit and finance, e. Lack of affordable childcare options, f. Lack of government policies to address gender gaps	a. Equal pay legislation, b. Affirmative action policies, c. Education and skills training programs for women, d. Government subsidies for women-owned businesses, e. Affordable childcare options	5	Yes		No
Male	25-34	Self-employed	No	3	a. Social norms, b. Discrimination, e. Lack of affordable childcare options	a. Equal pay legislation, c. Education and skills training programs for women, d. Government subsidies for women-owned businesses, e. Affordable childcare options	5	No		NO
Female	25-34	Self-employed	Yes	3	a. Social norms, b. Discrimination, c. Lack of education and skills training, d. Limited access to credit and finance, e. Lack of affordable childcare options, f. Lack of government policies to address gender gaps	b. Affirmative action policies, d. Government subsidies for women-owned businesses, e. Affordable childcare options	5	No		none
Female	45-54	Employed	Yes	4	b. Discrimination, e. Lack of affordable childcare options	d. Government subsidies for women-owned businesses, e. Affordable childcare options	5	Yes	not sure	no
Female	35-44	Employed	Yes	4	a. Social norms, e. Lack of affordable childcare options	a. Equal pay legislation, d. Government subsidies for women-owned businesses, e. Affordable childcare options	5	No		no
Female	45-54	Self-employed	Yes	2	b. Discrimination	a. Equal pay legislation, e. Affordable childcare options	5	Not sure		No comments
Female	18-24	Student	Not sure	5	a. Social norms, b. Discrimination, d. Limited access to credit and finance	a. Equal pay legislation, c. Education and skills training programs for women, d. Government subsidies for women-owned businesses, e. Affordable childcare options	5	Not sure		No
Female	18-24	Student	Yes	3	a. Social norms, b. Discrimination	a. Equal pay legislation, b. Affirmative action policies, c. Education and skills training programs for women, d. Government subsidies for women-owned businesses, e. Affordable childcare options	5	Not sure		No

Interpretation of the data from Table 2:

The data provided above is a survey of individuals from Albania, asking about their gender, age, occupation, and opinions on gender gaps in the Albanian labor market. The survey asked respondents whether they had experienced gender discrimination in their workplace, how they would rate the level of gender equality in Albania's labor market, what they believed were the main causes of gender gaps in Albania's economy, and what policies or programs they believed could be effective in reducing gender gaps.

Of the respondents, all identified as female except for one who preferred not to say and 3 males. The majority of respondents were aged between 18-24, with a smaller number aged between 25-34 and 35-44. Most respondents were employed, with a smaller number of students and retirees.

In terms of gender discrimination in the workplace, the majority of respondents reported not experiencing such discrimination, although a few were unsure. The respondents were generally critical of gender equality in Albania's labor market, with most rating it a 3 out of 5 or lower. The main causes of gender gaps identified by respondents were social norms, discrimination, lack of education and skills training, limited access to credit and finance, and lack of affordable childcare options. Respondents believed that policies and programs such as equal pay legislation, affirmative action policies, education and skills training programs for women, government subsidies for women-owned businesses, and affordable childcare options could be effective in reducing gender gaps in Albania's economy.

The majority of respondents believed it was important to address gender gaps in Albania's economy, although some were unsure. Few respondents had heard of specific policies or programs aimed at reducing gender gaps, although a few mentioned equal pay legislations, government subsidies for women-owned businesses, and affordable childcare options.

Overall, the survey data suggests that gender gaps are perceived as a significant issue in Albania's labor market, with a range of factors contributing to these gaps. Respondents identified several policies and programs that they believed could be effective in addressing these gaps, indicating that there is interest in and support for measures to promote gender equality in the Albanian economy.

4. ADDRESSING GENDER GAPS IN ALBANIA

Reducing gender gaps in Albania's economy requires a multi-faceted approach, encompassing policies, and programs aimed at promoting women's access to education and employment, as well as addressing social norms and discriminatory practices that hinder gender equality.

4.1 Review of existing policies and programs aimed at reducing gender gaps in Albania's economy

Albania has made significant progress in advancing gender equality in recent years, with the adoption of a number of laws and policies aimed at reducing gender gaps in various sectors, including education, employment, and political representation. These policies and programs include the National Action Plan for Gender Equality, the Law on Gender Equality, and the National Strategy for Gender Equality and Domestic Violence, among others [13].

4.2 Analysis of the effectiveness of these policies and programs

While these policies and programs have led to some improvements in gender equality in Albania, significant gaps remain, particularly in the labor market. Women continue to be under-represented in leadership positions and in high-paying occupations, and face discrimination and harassment in the workplace [10]. The effectiveness of existing policies and programs in addressing these challenges has been limited by inadequate implementation, insufficient resources, and a lack of coordination among stakeholders [13].

Most importantly, despite the availability of various programs that support women's participation in business, another problem which will also be discussed later is that evidence suggests that these programs are often unknown or underutilized by the public, or more specifically women.

4.3 Recommendations for improving policies and programs to address gender gaps in Albania

To effectively reduce gender gaps in Albania's economy, there is a need for stronger policy implementation, increased investment in women's education and employment, and efforts to change discriminatory social norms and attitudes. Specifically, policies and programs should focus on increasing women's access to education and training, promoting women's participation in the labor market, addressing gender-based discrimination and violence, and enhancing gender-responsive budgeting and planning [10;13]. Coordination among stakeholders, including government, civil society, and the private sector, is also critical to ensuring the sustainability and effectiveness of policies and programs aimed at reducing gender gaps.

Overall, addressing gender gaps in Albania's economy is an ongoing process that requires sustained commitment and collaboration among all actors, and a comprehensive approach that takes into account the complex and interrelated factors that contribute to gender inequality.

CONCLUSION

This paper has examined the intersection of gender and the economy in Albania, focusing on gender gaps in the labor market, their causes and economic impact, and existing policies and programs aimed at reducing them.

The analysis has shown that gender gaps in Albania's labor market persist, particularly in wages, employment, and occupational segregation. These gaps are caused by a complex set of factors, including social norms and stereotypes, discrimination, and policy barriers. The economic costs of gender gaps in Albania are significant, leading to lower productivity, slower economic growth, and reduced competitiveness.

Existing policies and programs aimed at reducing gender gaps in Albania's economy have had limited effectiveness, due to inadequate implementation, insufficient resources, and a lack of coordination among stakeholders. To address these challenges, policies and programs should focus on increasing women's access to education and training, promoting women's participation in the labor market, addressing gender-based discrimination and violence, and enhancing gender-responsive budgeting and planning.

The implications of these findings for policy and practice are clear. Albania needs to adopt a more comprehensive and sustained approach to reducing gender gaps in the economy, one that takes into account the multiple factors that contribute to gender inequality and engages all stakeholders. This will require a commitment to policy implementation, increased investment in education and training, and a focus on changing discriminatory social norms and attitudes.

Future research should build on this analysis by exploring in more detail the specific factors that contribute to gender gaps in Albania's labor market, as well as the effectiveness of different policy interventions aimed at reducing them. This research should also examine the broader social and cultural context that shapes gender norms and stereotypes, and how these impact women's economic opportunities.

Overall, reducing gender gaps in Albania's economy is a complex and long-term challenge, but one that is critical to achieving sustainable and inclusive economic growth. By adopting a comprehensive and evidence-based approach, Albania can make significant progress toward gender equality and a more prosperous and equitable future.

REFERENCES

[1] Cuberes, D., & Teignier, M. (2016). Aggregate effects of gender gaps in the labor market: A quantitative estimate. Journal of Human Capital, 10(1), 1-32. doi: 10.1086/684537

[2] Budria, S., & Swaffield, J. K. (2019). The gender wage gap and the role of education in Albania: Evidence from the Living Standards Measurement Study. Eastern European Economics, 57(1), 1-17. doi: 10.1080/00128775.2018.1488106

[3] World Economic Forum. (2021). The Global Gender Gap Report 2021. Retrieved from https://www3.weforum.org/docs/WEF_G

[4] World Bank. (2018). Albania Gender Assessment. Retrieved from https://openknowledge.worldbank.org/handle/10986/31084

[5] Kadhim-Saleh, A., Maguire, L., & Docherty, J. (2017). The effectiveness of foot care clinics on non-traumatic lower-limb amputation: A systematic review. Evidence-Based Medicine, 22(6), 188-195. http://dx.doi.org/10.1136/eb-2017-102699

[6] INSTAT. (2020). Labor Force Survey - 4th quarter 2019. Institute of Statistics of Albania. https://instat.gov.al/media/7646/labour_force_survey_q4_2019.pdf

[7] Kamberi, E. (2019). Gender Equality in Albania. Friedrich-Ebert-Stiftung. https://library.fes.de/pdf-files/bueros/albanien/15727.pdf

[8] World Bank. (2019). Albania Gender Assessment. World Bank Group. https://documents.worldbank.org/en/publication/documents-reports/documentdetail/451381574409163578/albania-gender-assessment-reducing-gender-gaps-for-more-inclusive-development

[9] USAID. (2019). Gender Analysis for Albania. United States Agency for International Development. https://www.usaid.gov/sites/default/files/documents/1866/ALBANIA-GENDER-ANALYSIS-REPORT-FINAL.pdf

[10] International Labour Organization (ILO). (2017). Women and men in the informal economy: A statistical picture. ILO.

[11] Organisation for Economic Co-operation and Development (OECD). (2020). Albania policy priorities for stronger, more inclusive and sustainable growth. OECD.

[12] ILOSTAT. (2022). ILOSTAT [Data visualization tool]. Retrieved from https://www.ilo.org/shinyapps/bulkexplorer37/

[13] Organisation for Security and Cooperation in Europe (OSCE). (2019). Advancing women's economic empowerment in Albania. OSCE.

Relationship between HDI, ICT and Economic Growth: Case of Albania

Vangjel Toto[1] *, Mirela Alhasani (Dubali)[2]

[1]*Department of Economics, Faculty of Economics and Administrative Sciences, EPOKA University, Autostrada Tiranë-Rinas, km. 12, 1032, Tirana, Albania*
[2]*Center for European Studies, Faculty of Law and Social Sciences, EPOKA University, Autostrada Tiranë-Rinas, km. 12, 1032, Tirana, Albania*
[*]*Corresponding Author: vtoto19@epoka.edu.al;*

Abstract

The aim of this research paper is to study the relationship between information and communication technology (ICT), economic growth, and the human development index (HDI) in Albania. To avoid omitted variable bias (OVB) urbanization have been used as a control variable in the model. In order to investigate the relationship between the mention variables, an autoregressive distributed lag (ARDL) bound testing and vector error correction model (VECM) approach have been performed for the period from 1996 to 2021. The empirical results show that ICT is a positive and significant determinant of the human development index. The studied variables does not have a long – run relationship but satisfy a short – run equilibrium. Lastly, a Granger – causality test is done to all variables and results show that only ICT Granger – causes urbanization.

Keywords: *Human Development Index, ICT, ARDL bound testing, VECM, Albania.*

1. INTRODUCTION

People are considered to be very important in the production process and consequently in the economic life a country. In order to measure the efficiency and differences among people, social scientist have decided to develop an index called Human Development Index (HDI). World Bank defines HCI as the magnitude of current healthcare and educational system on the efficiency of the future worker generation. For the first time it have been published in the report of United Nations Development Program (UNDP) on 1990 as a necessity for comparison between countries regarding the welfare and efficiency of citizens based on three main pillars, such as: health, education and economic metric. The concept of HDI, embodies the Amartya Sen's 'capabilities' approach, which mentions that is more important the endings like a desirable standard of life compared to high GDP per income [14].

Based on the report published by the UNDP regarding the HDI values among different countries around the world, Albania is considered as a high human development country with an index of 0.796 and ranked as the 68th country in world. Compared to other countries in the Western Balkans, Albania is ranked the third after Montenegro and Serbia which are considered as high human development countries, respectively ranked in the 52nd and 62nd position. Even though Albania has a higher life expectancy compared to both countries and years of schooling are approximately the same, the divergence comes from the considerable differences in the economic variable represented by Gross National Income (GNI) per capita.

[7] found that SME-s in Albania are facing the majority of the difficulties and challenges in the market. Their primary challenge is financing, companies have to waste a lot of time on fulfilling banks pre-requirements and high interest rates. Author states that this problem disadvantages Albania compared to the reaming countries of the region. Although, SME-s face a lot of costs on the initial steps of the business. Other studies show that high presence of ICT in the country tend to decrease the costs for the business start-ups or SME-s which will result in higher economic conditions and better human development.

Due to the fact that ICT plays a very important role on the human development index (HDI) and there is a literacy gap regarding the association of ICT with HDI in the case of Albania we decided to study the relationship between human development index, economic growth and ICT. The main purpose of this research paper is to investigate the determinants of Human Development Index (HDI) in Albania for the period 1996 – 2021 using ARDL bound testing and VECM approach. Although this paper will investigate if there is any Granger causality between the selected variables.

The rest of the research paper is structured as follows, in Section 2 is presented the Literature Review. Section 3 will represent the data sources and econometric methodology used in this study, while section 4 will show the empirical results and discussions on them. Paper will conclude with section 5.

H1: There is a long – run equilibrium between Human Development Index, ICT and economic Growth

H2: There is a short – run equilibrium between Human Development Index, ICT and economic Growth

H3: Economic growth Granger – causes increase in the ICT

2. MATERIALS AND METHODS

2.1. Literature review

There are numerous studies analyzing the determinants of the Human Development Index (HDI). The majority of them use the panel data techniques in order to find the relationship between variables. On its own, the Human Development Index is calculated as a geometric mean of the educational index, schooling index, and health index. But there are even other scholars that give their ways how calculating the HDI.

[2], analyzed the determinants of HDI for ten countries of the Association of Southeast Asian Nations (ASEAN) for the period from 2000 to 2015 using a panel regression technique with fixed effects model. The author found that for these groups of countries, population and per capita of income growth affect the dependent variable. For this reason, author suggest policymakers to design plans for population control and secondly find ways to stimulate economic growth. The HDI determinants of countries in this region were studied even in the paper of [12]. He inspected the HDI determinants of eight Buddhist countries from 2010 up to 2015 using panel data technique with random effects model. As in the paper of [2] it was found that gross domestic product per capita affects positively the HDI but [12] found that even inflation, life expectancy and fertility level are significant determinants.

[4] reached the same conclusions with [12] even though the countries taken into analyses had totally other HDI parameters and the empirical techniques were different. [4] studied eighty-four countries classified as very high and high human developed published in the report of UNDP for the year 2011. Authors carried out logit, probit and Tobit models in order to find out the determinants of HDI. According to the paper's conclusion, all three models point to key HDI predictors to be the gross domestic product per capita, life expectancy at birth, anticipated years of schooling, and labor participation rate.

[13] have analyzed the determinants of HDI from a larger perspective compared to the up mentioned authors. He conducted a cross-sectional analysis for all the countries of the world and after stratified the results based on broad regions. The results showed that GDP per capita, life expectancy, literacy rate, GINI coefficient, fertility rate and emission of CO2 are all statistically significant in the HDI. Moreover, he showed that Sub – Saharan Africa is the region with the lowest levels of the Human Development Index while the Europe and Central Asia the highest even though the highest level of gross national income per capita was

for the Arab countries. In this continental approach was carried out even in the study of [10]. The authors used a proportionally stratified sample of 182 from 253 countries of the world. The aim of this paper was to show if there is any continental difference regarding the Human Development Index (HDI). In order to perform this analysis, the ANOVA test and Bonferroni Post Hoc Test were conducted. Empirical results show that Africa's mean value of HDI is 0.536 which is even lower to the cutoff value of 0.600 which represents a poor index while the European continent has performed better than all the other having a HDI mean of 0.845 higher than the cutoff point of 0.800 for very high human index. These results reinforce more the necessity to intervene in the educational and healthcare system of African countries.

[3] studied the HDI for 130 countries of the world for the period from 2009 up to 2014 using a Bayesian ordered probit model. The results showed that even though there is a positive correlation between variables, only GDP and internet users are significant. According to [1], ICT is crucial for the diffusion of technology, which is the only means to simultaneously bring about innovation, lower manufacturing costs, and improve quality. Other authors have likewise come to similar conclusion.

[9] investigated the relationship between ICT, economic growth and HDI for the period from 1990 up to 2014 for Pakistan using ARDL-bound testing approach. Authors found that ICT is a strong determinant of HDI but although accelerates economic growth in different aspects such as international trade. For this reason, authors recommend the policymakers of Pakistan to invest in information and communication technology (ICT). The same reaches and [8] who studied the same relationship as [9] but for five countries of South Asia over the period 1990 – 2016. Even this panel data analysis shows the strong significance of ICT and economic growth on HDI and the necessity to develop new policies regarding ICT.

There have not been any previous studies regarding the case of Albania explicitly, but [5] made comparison analyses between Western Balkan and European Union countries regarding the economic welfare measured by HDI for the period 2009 – 2018. Authors conclude that in terms of corruption, economic freedom and urbanization, EU countries performed better. Prior studies have not studied the case of Albania in a time-series approach, neither have investigated the impact of ICT and its relationship with economic growth and HDI by using ARDL-bound testing approach.

2.2. Data and Methods

The data used in this research paper are retrieved from the World Bank open Data and Human Development Report for the period 1996 – 2021. The time frame for this study was chosen based on the data that were available. The empirical model aims to explain Human Development Index in terms of Gross Domestic product per capita and Information and Communication Technology (ICT). The econometric tests will be performed by EViews 10 software.

Table 1: Measurement units of variable, definition, indicators and data collection source

Indicator	Variable	Source	Definition
HDI	Human Development Index	Human Development Report	HDI is the geometric mean of health, education and economic variable
GDPPC	Gross Domestic Product per Capita	WORLD BANK	The annual growth rate of real GDP based on local currency
ICT	Information and Communication Technology	WORLD BANK	Annual penetration of mobile per 100 citizens

URB	Urbanization	WORLD BANK	The standard of living for those who live in cities

In the model is used urbanization as a control variable in order to protect the model from Omitted Variable Bias (OVB). Based on the previous literature, in the original model were included even Foreign Direct Investments (FDI) and Trade openness as control variables but due to very high correlation between variables, the variables were not included in the final econometric model. In order not to suffer from heteroscedasticity, all the variables were taken into the logarithmic form. This econometric model is presented in the following equation:

$$\mathrm{LogHDI}_t = \beta_0 + \beta_{1t}\mathrm{LogGDP}_t + \beta_{2t}\mathrm{LogICT}_t + \beta_{3t}\mathrm{LogURB}_t + \varepsilon_t \qquad (1)$$

In this research paper, we expect all three beta-estimates to be positive and significant in the determination of the Human Development Index.

Initially, it is necessary to test for the stationarity of all variables by conducting the Unit-Root test through the [6]. In order to investigate the short and long-run relationship between the mentioned variables we will apply the ARDL bounding testing approach proposed by [11] and VECM. It is decided to select this testing approach for several reasons. The ARDL bounding testing is reliable when the variables are a mix of level and first-order integrated. It generates reliable results in cases where the dataset is small. Thirdly, the long-run equilibrium can be generated through a simple linear transformation without losing long-run information. Lastly, a Granger-causality test will be conducted between the gross domestic product per capita and ICT.

3. RESULTS AND DISCUSSION

3.1. Unit Root Test

In order to advance with the empirical model, initially it is obligatory to test the stationarity of the variables. This process is done through Unit Root testing using the Augment Dicky – Fuller method. The results show that GDP per capita and Human Development Index (HDI) are first-order integrated I(1) while the ICT variables is level integrated I(0). The urbanization variable is taken into the first difference in order to satisfy the ARDL bound testing requirements. Even this variable is first-order integrated. All the results are statistically significant in a significance level of 1%. These results permit us to continue with the ARDL-bound testing.

Table 2: Unit Root Test

Variable	Proxy	t-statistic	p-Value	Level	Stationarity
LGDPPC	GDP per capita	-0.836985	0.7908	I(0)	Not stationary
LGDPPC	GDP per capita	-5.22739	0.0003	I(1)	Stationary
LHDI	Human Development Index	-1.656914	0.4399	I(0)	Not stationary
LHDI	Human Development Index	-5.967534	0.0001	I(1)	Stationary
LPOV	ICT	-3.680719	0.0110	I(0)	Stationary
LDURB	Urbanization	-1.471581	0.5304	I(0)	Not stationary
LDURB	Urbanization	-4.254706	0.0032	I(1)	Stationary

Source: Own Estimates

3.2. Cointegration test

The aim of this paper is to investigate the short and long – run relationship between ICT, economic growth and Human Development Index (HDI). This will be done by the ARDL bound testing and VECM approach.

Based on the results generated from the ARDL bound testing there is no equilibrium between these three variables in the long run. This means that in the long – run there is no implication of ICT and economic growth on HDI, this result rejects the first hypothesis.

On the other hand, the results shown in table 3 are the ones generated after the VECM test was conducted. There we can see that all variables are statistically significant at a significance level of 10% and confirming the fact that variables are cointegrated in the short – run. This result confirms the second hypothesis.

The coefficient of ICT has a positive and significant effect on the dependent variable. The estimate shows that 1% increase in ICT increases HDI by 0.3192%. This result is expected because improvement in technology, impacts immediately the human development process. This variable improves the healthcare system in developing countries because citizens in rural areas can't pay a visit to the doctor frequently so they use their mobile as a mean of communication with the healthcare system and receive more information about their health. In Albania, there are some e-health platforms that give opportunity to citizens around the country to communicate with doctors and receive remote assistance. In addition, ICT impacts on education although. Students in every corner of the country may receive online courses without the obligation to leave their homes. Positive implications are found even between ICT and economy. Communication technology helps businesses to improve the efficiency and decreases production costs or establish cooperation with different companies in the world. In addition, it is the only way to tackle the endemic problem of corruption.

The empirical estimates confirm although that there is a statistically and significant relationship between the GDP per capita and HDI. A 1% increase in GDP per capita, improves HDI by 0.76%. Improvements in economic growth would affect directly the economic component of HDI. Higher economic growth means higher human development. In order to increase economic growth, Albanian government should develop policies that fight market inefficiencies mainly driven by unfair market structures. Moreover, urbanization accelerates significantly HDI. This result is expected for a developing country like Albania where majority of healthcare assistance, education institutions and work opportunities are found in the capital city of the country.

The cointegration factor is found to be statistically significant which confirms the short – run equilibrium between the variables.

Table 3: VECM Regression

ECM Regression
Case 2: Restricted Constant and No Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LHDI(-1))	-4.308073	0.568564	-7.577107	0.0835
D(LHDI(-2))	-3.030886	0.463815	-6.534684	0.0967
D(LHDI(-3))	0.181164	0.126890	1.427726	0.3890
D(LGDPPC)	0.761771	0.093099	8.182396	0.0774
D(LGDPPC(-1))	-0.059840	0.028197	-2.122220	0.2803
D(LGDPPC(-2))	0.235775	0.040802	5.778450	0.1091
D(LGDPPC(-3))	-0.350583	0.051318	-6.831579	0.0925

D(LICT)	0.319288	0.041611	7.673155	0.0825
D(LICT(-1))	0.140781	0.019823	7.101853	0.0891
D(LICT(-2))	0.224239	0.032288	6.945072	0.0910
D(LICT(-3))	0.263516	0.037689	6.991923	0.0904
D(DLURB)	26.97502	3.825376	7.051601	0.0897
D(DLURB(-1))	-42.91219	5.893657	-7.281080	0.0869
D(DLURB(-2))	-45.82914	6.329892	-7.240115	0.0874
D(DLURB(-3))	-13.31471	1.944999	-6.845612	0.0923
CointEq(-1)*	0.384232	0.049510	7.760754	0.0816

R-squared	0.952043	Mean dependent var	0.007711
Adjusted R-squared	0.808173	S.D. dependent var	0.014017
S.E. of regression	0.006139	Akaike info criterion	-7.259534
Sum squared resid	0.000188	Schwarz criterion	-6.463707
Log likelihood	92.22510	Hannan-Quinn criter.	-7.086819
Durbin-Watson stat	3.264293		

* p-value incompatible with t-Bounds distribution.

Source: Own Estimates

3.3. Granger-causality

The last step of this research paper is to test if there is any Granger-causality between the studied variables. The main important causality is the one between economic growth and ICT. Based on the results generated from the model, we fail to prove that economic growth Granger – causes ICT which rejects the third hypothesis. The only relationship we may observe between the variables is that ICT Granger – causes urbanization.

Table 5: Granger – Causality

Causality Direction	F-statistic	p - Value
ICT ⟶ HDI	0.73666	0.4919
HDI ⟶ ICT	0.31293	0.7350
GDPPC ⟶ HDI	0.95508	0.4025
HDI ⟶ GDPPC	1.31433	0.2920
URB ⟶ HDI	0.86679	0.4371
HDI ⟶ URB	0.60358	0.5575
GDPPC ⟶ ICT	0.58604	0.5665
ICT ⟶ GDPPC	1.71205	0.2072
URB ⟶ ICT	0.12002	0.8876
ICT ⟶ URB	23.0387	0.0000
URB ⟶ GDPPC	0.39633	0.6785
GDPPC ⟶ URB	0.57398	0.5733

Source: Own Estimates

4. CONCLUSION

This study aims to determine the relationship between Albania's Human Development Index (HDI), economic growth, and information and communications technology (ICT) from 1996 through 2021. This study was motivated by the literacy gap regarding the relationship between ICT and HDI. In order to examine the relationship between the variables it was decided to use ARDL bound testing and VECM approach. The empirical model shows that ICT is a strong determinant of HDI. This confirms that technology may improve the standard of living in all dimensions. In the case of Albania, it is most necessary for the economic growth of the country. Moreover, GDP per capita is a positive and significant determinant of the HDI. In addition, the paper shows that there is only a short-run equilibrium between the studied variables and ICT Granger – causes urbanization.

As expected, economic growth affects positively the Human Development Index but importance should be placed to the ICT variable. It is the only way for sustainable economic growth through more SMEs, lower costs of production, more openness to the international market, and which is more important in Albania, lower levels of corruption.

Future studies may improve the literature by using alternative methodologies.

REFERENCES

[1] Adenle, A. A., Azadi, H., & Arbiol, J. (2015). Global assessment of technological innovation for climate change adaptation and mitigation in developing world. *Journal of environmental management, 161*, 261-275.

[2] Arisman, A. (2018). Determinant of Human Development Index in ASEAN Countries. *Signifikan, 7(1)*, 113-122.

[3] Çağlayan-Akay, E., & Van, M. H. (2017). Determinants of the Levels of Development Based on the Human Development Index: Bayesian Ordered Probit Model. *International Journal of Economics and Financial Issues*, 245-431.

[4] Eren, M., Çelik, A. K., & Kubat, A. (2014). Determinants of the Levels of Development Based on the Human Development Index: A Comparison of Regression Models for Limited Dependent Variables . *Review of European Studies. Vol. 6 (1)*, 10-23.

[5] Feruni, N., Hysa, E., Pnait, M., Rădulescu, I., & Brezoi, A. (2020). The Impact of Corruption, Economic Freedom and Urbanization on Economic Development: Western Balkans versus EU-27. *Sustainability, 12(22)*, 9743.

[6] Fuller, W. A. (1976). Introduction to Statistical Time Series, New York, John Wiley and Sons.

[7] Hysa, E. (2014). Inequality and Human Development Correlation in Albania. *Proceedings in GV-Global Virtual Conference*.

[8] Iqbal, K., Hassan, S. T., & Peng, H. (2019). Analyzing the role of information and telecommunication technology in human development: panel data analysis. *Environmental Science and Pollution Research, 26*, 15153-15161.

[9] Khan, N. H., Ju, Y., & Hassan, S. T. (2019). Investigating the determinants of human development index in Pakistan: an empirical analysis. *Environemental Science and Pollution Research*, 19294-19304.

[10] Kpolovie, P. J., Ewansiha, S., & Esara, M. (2017). Continental Comparison of Human Development Index (HDI). *International Journal of Humanities Social Sciences and Education (IJHSSE) Volume 4, Issue 1*, 9-27.

[11] Pesaran, M., Shin, Y., & Smith, R. Y. (2001). Bounds Testing approaches to the analysis of level relationships. *Journal of applied econometrics 16, no. 3*, 289-326.

[12] Sanganji, J. (2016). The Determinants of Human Development Index in Several Buddhist Countries . *Journal of Buddhist Education and Research 2.1*, 48-60.

[13] Shah, S. (2016). Determinant of Huan Development Index: A Cross-Country Empirical Analysis. *Munich Personal RePEc Archive (MRPA) Paper No. 73759*.

[14] Stanton, E. A. (2007). The Human Development Index: A History. *Global Development and Environment Institute*, 127.

[15] THE WORLD BANK. (2023). *Human Capital Project*. Retrieved from worldbank.org: https://www.worldbank.org/en/publication/human-capital

[16] UNDP. (1990). *HUMAN DEVELOPMENT REPORT.* New York: Oxford University Press.

The Glass Ceiling impacts Women's Careers. The Case of Albania

Klea Pashtranjaku[1]*, Mirela Alhasani (Dubali)[2]*

[1]*Department of Business Administration, Faculty of Economics and Administrative Sciences, EPOKA University, Autostrada Tiranë-Rinas, km. 12, 1032, Tirana, Albania*
[2]*Center for European Studies, Faculty of Law and Social Sciences, EPOKA University, Autostrada Tiranë-Rinas, km. 12, 1032, Tirana, Albania*
Corresponding author: kpashtranjaku19@epoka.edu.al, malhasani@epoka.edu.al;

Abstract

The purpose of this research paper is to investigate the issue of the glass ceiling and its effect on the professional lives of Albanian women. Despite their skills and abilities, many women continue to face the "glass ceiling," which is a barrier that stops them from rising in their employment. This study focuses on the obstacles that Albanian women face in their career growth owing to the glass ceiling and suggests viable ways to overcome these barriers. Specifically, the study looks at how the glass ceiling affects career advancement for Albanian women. The information required for this study came from the responses of thirty working women from the Albanian country. According to the findings, the glass ceiling does in fact exist in Albania, and it has a negative impact on the options available to women for career progression, particularly in fields that are mainly held by men. The data also imply that gender preconceptions and cultural norms play a substantial role in the maintenance of the glass ceiling. In conclusion, this study proposes a number of solutions that can be implemented by individuals, businesses, and government agencies to break through the glass ceiling and advance gender equality in the workplace.

Thesis statement

I contend that there is a negative correlation between the glass ceiling effect and the career advancement of women.

Research questions

What are the factors that contribute to the prevalence of the glass ceiling effect?

What is the impact of the glass ceiling effect on woman's career development?

1. INTRODUCTION

A pervasive and persistent obstacle that has a substantial impact on the ability of women to develop their careers is referred to as the "glass ceiling." The glass ceiling is still a substantial obstacle in many businesses around the world, despite the fact that there has been significant progress made in recent years toward gender equality. It is a multifaceted problem that has its roots in a variety of issues, such as cultural views, societal expectations, and institutional practices that restrict the number of professional options available to women and the level of professional advancement they can achieve.

The phrase "glass ceiling" was used in the 1980s to characterize the obstacles that prohibit women from ascending to the top levels of management in the business sector. These obstacles are commonly referred to as the "glass ceiling." Since that time, researchers have broadened their scope to investigate how the glass ceiling affects women working in a wider variety of industries and occupations. Research conducted all around the world have come to the conclusion that women face the glass ceiling in a variety of settings, and that this has a detrimental effect on their professional lives, levels of happiness in the workplace, and overall well-being.44% of women in Albania participate in the labor force. A significant proportion of these women are still employed in agriculture and the informal sector of industry. The issue that must be asked is how many women genuinely hold positions of power in the highest levels of management, and the answer is extremely few. This is especially true for the commercial banking business in Albania, where the number of women in top executive management positions (such as CEOs, deputy CEOs, and firm board members) is low compared to the number of men. Cooper (2001) states, "The causes for this disparity are diverse in nature and are sometimes referred to as 'barriers' or 'obstacles' that women confront in advancing their careers. These impediments are frequently the result of gender and ethnicity, and not a lack of aptitude to handle positions at higher institutional levels.

2. LITERATURE REVIEW

This literature review aims to examine the various ways the glass ceiling impacts women's careers and how it affects their ability to advance in their careers.

2.1 Gender Bias and Stereotypes:

Gender bias and stereotypes are one of the most significant barriers that women face in their careers. According to Heilman and Parks-Stamm (2007), gender stereotypes can affect the perception of women's competence and leadership ability, which can lead to discrimination in hiring, promotion, and pay decisions. This bias creates a situation where women's capabilities are undervalued and underutilized, limiting their potential for advancement.

2.2 Lack of Mentorship and Sponsorship:

Mentorship and sponsorship are essential tools for career advancement, yet women face significant barriers in securing these opportunities. According to Ragins and Cotton (1999), women have a harder time finding a mentor or sponsor who is willing to advocate for them, provide guidance, and help them network. This lack of support can limit women's access to key information, knowledge, and resources, making it more challenging for them to advance in their careers.

2.3 Unequal Pay:

The gender pay gap is a well-documented issue that affects women across all professions and industries. Women earn less than men in nearly every job and at every level, according to a report by the National

Women's Law Center (2020). This disparity in pay creates a significant barrier to advancement, as women may not have the financial means to access higher education or training that could help them acquire the skills and knowledge necessary to advance in their careers.

2.4 Limited Access to Leadership Roles:

Women are often underrepresented in leadership positions, particularly in high-level management and executive roles. According to Catalyst (2021), women hold just 29% of senior management roles globally. This lack of representation makes it more challenging for women to access critical networks, mentoring, and sponsorship opportunities that can help them advance their careers.

2.5 Workplace Culture:

The workplace culture can be a significant barrier to women's career advancement, particularly in male-dominated industries. According to a report by McKinsey & Company (2020), women are more likely to experience discrimination, harassment, and bias in the workplace. This can create a hostile work environment that makes it more challenging for women to perform at their best and limits their ability to advance in their careers.

In a study of women executives in Australia, Kramar, Bartram, and De Cieri (2011) found that the glass ceiling was a significant challenge for women's career advancement. The study identified a number of factors contributing to the glass ceiling, including cultural stereotypes and gender bias, a lack of support for work-life balance, and limited access to networks and mentors. The authors suggest that organizations can address the glass ceiling by promoting gender diversity and implementing policies that support work-life balance.

A study by Hymowitz and Schellhardt (1986) coined the term "glass ceiling" to describe the invisible barrier that limits women's access to top management positions. The study found that women faced a variety of barriers to career advancement, including discrimination, stereotyping, and exclusion from informal networks. The authors suggest that organizations can address the glass ceiling by implementing affirmative action programs, providing leadership training and mentoring, and creating more flexible work arrangements.

Huse and Solberg (2006) investigated the impact of the glass ceiling on women in senior management positions. The study found that women faced a number of barriers to career advancement, including a lack of access to informal networks and exclusion from decision-making processes. The authors suggest that organizations can address the glass ceiling by promoting gender diversity in leadership, providing leadership training and mentoring, and implementing family-friendly policies.

A study by Coccia, Lapierre, and Sénécal (2020) explored the impact of the glass ceiling on the well-being and career intentions of women in Canada. The study found that women who perceived the glass ceiling as a significant barrier to their career advancement experienced lower levels of well-being and were less likely to pursue high-level positions in their organizations. The study also highlighted the need for organizational leaders to address the underlying causes of the glass ceiling, such as gender discrimination, lack of mentorship and sponsorship, and limited access to professional development opportunities.

Bendl, Fleischmann, and Schmidt (2018) examined the impact of the glass ceiling on women's careers in Austria, Germany, and Switzerland. The study found that women faced significant barriers to career advancement, including gender stereotypes, lack of leadership development opportunities, and discrimination based on gender. The study also found that women who experienced the glass ceiling reported higher levels of stress, lower job satisfaction, and less commitment to their organizations. The study recommended that organizations should adopt strategies that promote gender diversity, provide support for work-life balance, and encourage mentorship and sponsorship programs for women.

Ellemers, Rink, and Derks (2016) explored the impact of the glass ceiling on women's careers in the Netherlands. The study found that women were more likely to experience the glass ceiling when they worked in male-dominated industries, had a high need for achievement, and faced gender stereotypes that portrayed women as less competent than men. The study also found that the glass ceiling had a negative impact on women's career motivation and job satisfaction. The study suggested that organizations should address the underlying causes of the glass ceiling by promoting gender equality in recruitment, retention, and promotion practices.

This literature review explores the impact of the glass ceiling on women's careers in Albania.

A study conducted by Rroshi, Sulo, and Dervishi (2018) found that gender inequality is a significant issue in Albanian workplaces. The study revealed that women face a variety of challenges, including lower pay, limited access to training and development opportunities, and limited opportunities for career advancement. The study also found that gender discrimination is a common experience among women in the workplace, and this discrimination often prevents women from reaching high-level positions in organizations.

Another study conducted by Kraja, Isaraj, and Prendi (2017) examined the challenges that women face in their career development in Albania. The study found that women often lack the necessary skills and qualifications for high-level positions, and this is due to a lack of access to training and development opportunities. The study also revealed that the glass ceiling is a significant barrier for women, and it prevents them from reaching high-level positions in organizations.

Seiti, Shtjefni, and Kapisyzi (2017), the authors examined the impact of the glass ceiling on women's careers in Albania. The study found that women face a range of barriers in their career development, including gender stereotypes, limited access to mentorship and networking opportunities, and discrimination based on gender. The study also found that the glass ceiling is a significant barrier for women, and it prevents them from reaching high-level positions in organizations.

In a more recent study by Cela and Kraja (2021), the authors examined the impact of gender stereotypes on women's career advancement in Albania. The study found that gender stereotypes are a significant barrier for women, and they often prevent women from pursuing careers in male-dominated industries. The study also revealed that gender stereotypes are prevalent in Albanian society and are reinforced by cultural and social norms.

Despite progress towards gender equality in recent years, the glass ceiling remains a significant challenge for women in the workplace. The glass ceiling is a barrier that limits women's access to career opportunities and advancement, and has a negative impact on their career satisfaction, well-being, and economic status.

According to a recent report by the World Economic Forum (WEF), Albania ranks 48th out of 153 countries in terms of gender equality. While the country has made progress in some areas, women in Albania still face significant barriers to career advancement. The glass ceiling is a particularly pressing issue, with women underrepresented in leadership positions and experiencing discrimination and bias in the workplace.

A study by Sopjani and Ramadani (2019) investigated the impact of the glass ceiling on women's careers in Albania. The study found that women face significant barriers to career advancement, including discrimination based on gender, lack of access to training and development opportunities, and cultural expectations that prioritize family over career. The study also found that women who perceive the glass ceiling as a significant barrier to their career advancement experience lower levels of job satisfaction and well-being.

In addition to discrimination and bias, the glass ceiling in Albania is also perpetuated by cultural attitudes and expectations that prioritize male leadership and dominance in the workplace. Studies have found that

traditional gender roles and patriarchal attitudes remain prevalent in Albanian society, and that these attitudes are reflected in the workplace (Albanian Centre for Population and Development, 2018).

To address the glass ceiling in Albania, it is important for organizations and policymakers to promote gender equality in recruitment, retention, and promotion practices. This could include implementing affirmative action programs, providing support for work-life balance, and encouraging mentorship and sponsorship programs for women.

One example of a successful initiative to address the glass ceiling in Albania is the Women in Business program, implemented by the European Bank for Reconstruction and Development (EBRD) in partnership with local organizations. The program provides training, mentorship, and networking opportunities for women entrepreneurs and business owners, with a focus on increasing access to finance and markets (EBRD, 2021).

In Albania, gender discrimination is a prevalent issue in the workplace. According to a study by the International Labor Organization (ILO) (2016), women in Albania face significant barriers in accessing higher-level positions, with men being more likely to occupy managerial positions. The study also found that women are often paid less than men for the same work and are less likely to receive promotions or training opportunities.

Another study by the Friedrich Ebert Foundation (FEF) (2017) revealed that women in Albania face significant challenges in advancing their careers due to gender discrimination and stereotypes. The study found that women's access to leadership positions is limited by male-dominated work cultures and a lack of support from male colleagues and superiors. The study also identified the need for policies and practices that promote equal opportunities for women in the workplace and address gender discrimination.

Despite the limited research on the topic in Albania, it is clear that the glass ceiling remains a significant barrier for women's career advancement. Addressing the issue requires a concerted effort from government, employers, and society at large to promote gender equality in the workplace and ensure equal opportunities for women. This could be achieved through policy interventions, such as affirmative action, gender-based budgeting, and the promotion of gender-sensitive workplace practices that aim to reduce gender discrimination and promote gender diversity.

3. METHODOLOGY

Research design: The study will use a quantitative research design with a cross-sectional approach, aiming to measure the impact of the glass ceiling on women's careers in Albania.

Sampling: A convenience sample of thirty working women will be selected for this study. Participants will be selected based on their availability and willingness to participate in the survey. It is important to note that a convenience sample may limit the generalizability of the findings to the larger population.

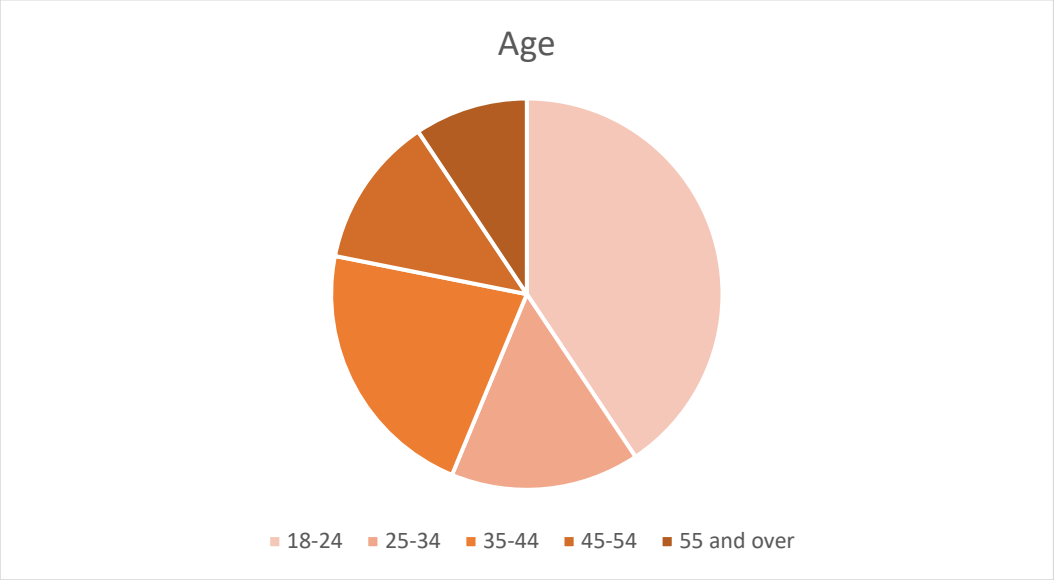
Data collection: A survey questionnaire will be designed to collect data from the participants. The questionnaire will include multiple-choice answers. The survey questions will be designed to measure the participants' experiences with the glass ceiling, including the barriers they faced, the impact on their career progression, and their perceptions of workplace gender equality.

Data analysis: Descriptive statistics will be used to analyze the quantitative data collected from the survey. The analysis will include frequency distributions, percentages, and means. The survey responses will be analyzed using statistical software such as SPSS or Excel.

4. RESULTS

Age frequency

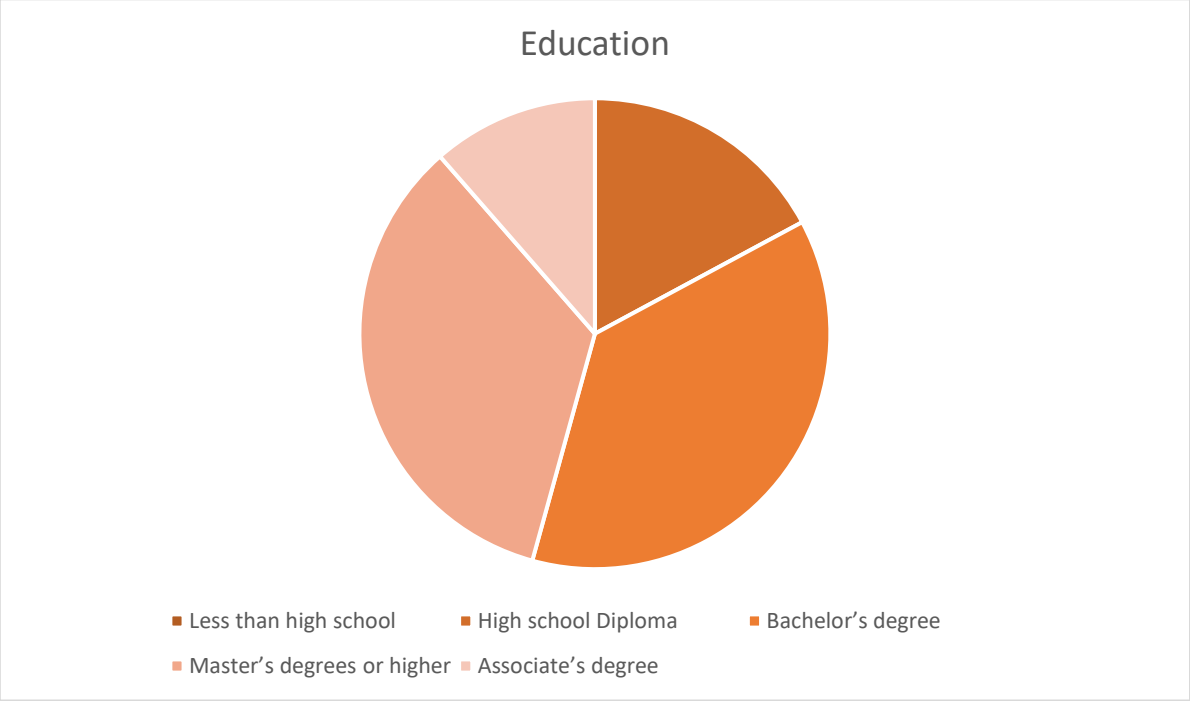
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Under 18	3	8.6	8.6	8.6
	18-24	13	37.1	37.1	45.7
	25-34	5	14.3	14.3	60
	35-44	7	20	20	80
	45-54	4	11.4	11.4	91.4
	55 or over	3	8.6	8.6	100.0
	Total	35	100.0	100.0	



The data shows the distribution of participants in different age groups. The largest group is the 18-24 age group, accounting for 37.1% of the sample. The second largest group is the 35-44 age group, accounting for 20% of the sample. The smallest group is the 55 or over age group, accounting for only 8.6% of the sample. The cumulative percent column indicates the total percent of participants up to each age group.

Education frequency

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Less than high school	0	0	0	0
	High school Diploma	6	17.1	17.1	17.1
	Bachelor's degree	13	37.1	37.1	54.2
	Master's degrees or higher	12	34.3	34.3	88.4
	Associate's degree	4	11.4	11.4	100
	Total	35	100	100	

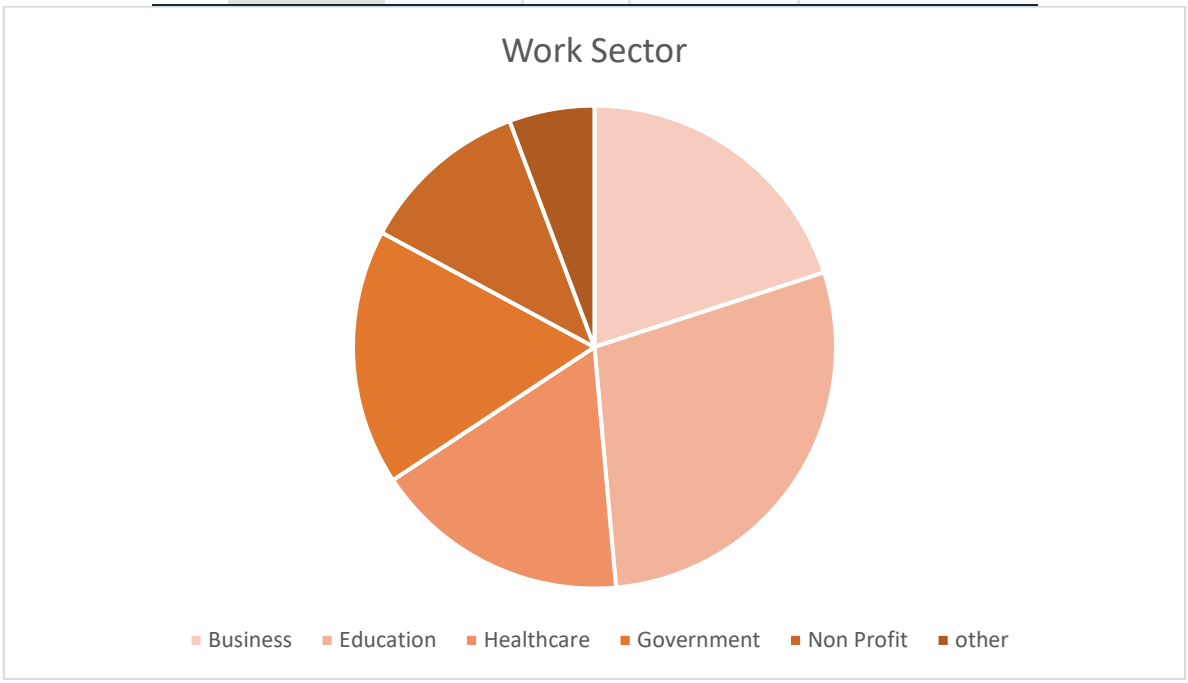


The data shows the distribution of educational levels among the respondents. The majority of the respondents, 37.1%, held a bachelor's degree, while 34.3% held a master's degree or higher. 17.1% of the respondents held a high school diploma, and 11.4% held an associate's degree. No respondents reported having less than a high school education.

The cumulative percentage shows that 54.2% of the respondents had at least a bachelor's degree, and 88.4% had a master's degree or higher, indicating that the sample was relatively well-educated. These findings suggest that the research sample was likely comprised of a highly skilled and educated group of individuals.

Work sector frequency

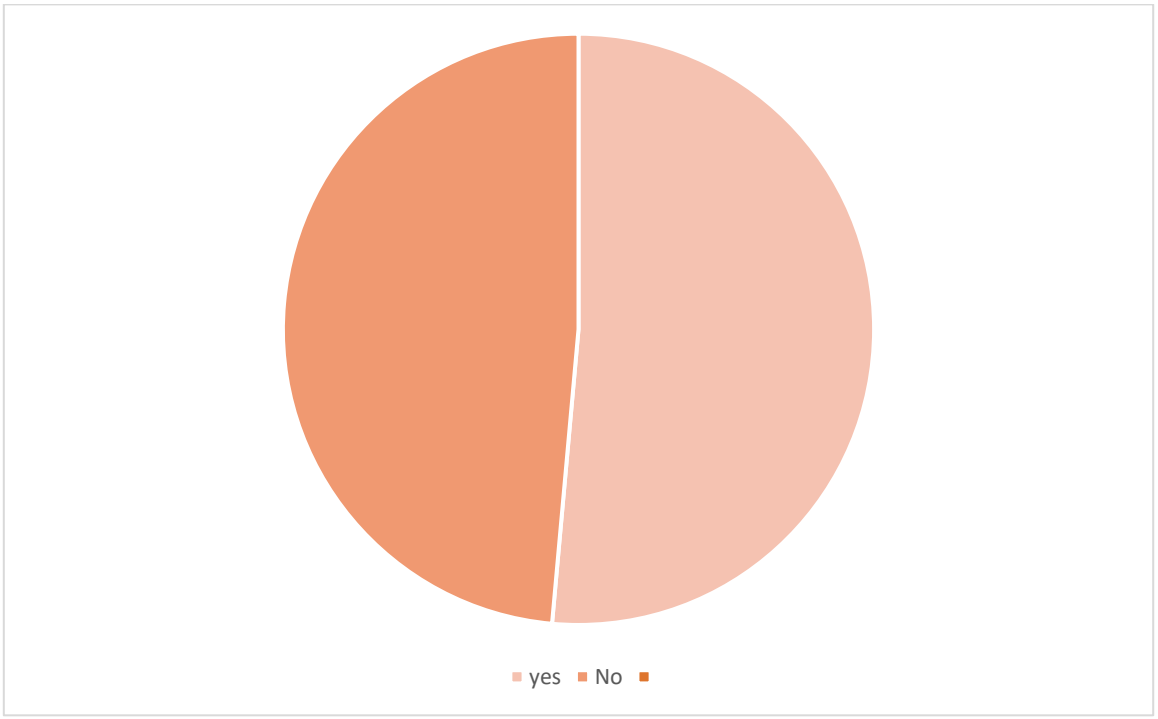
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Business	7	20	20	20
	Education	10	28.6	28.6	48.6
	Healthcare	6	17.1	17.1	65.7
	Government	6	17.1	17.1	82.8
	Non Profit	4	11.4	11.4	94.2
	Other	2	5.7	5.7	100
	Total	35	100	100	



The data represents the distribution of the participants' professions in different fields. The majority of the participants have their professions in the fields of education (28.6%) and business (20%). Healthcare and government sectors each have 17.1% of the participants. Non-profit organizations have 11.4%, while 5.7% of the participants have professions in other fields. The cumulative percent for each category shows the proportion of participants whose professions fall into that category and all previous categories.

Have you ever felt that you were passed over for a promotion or job opportunity because of your gender?

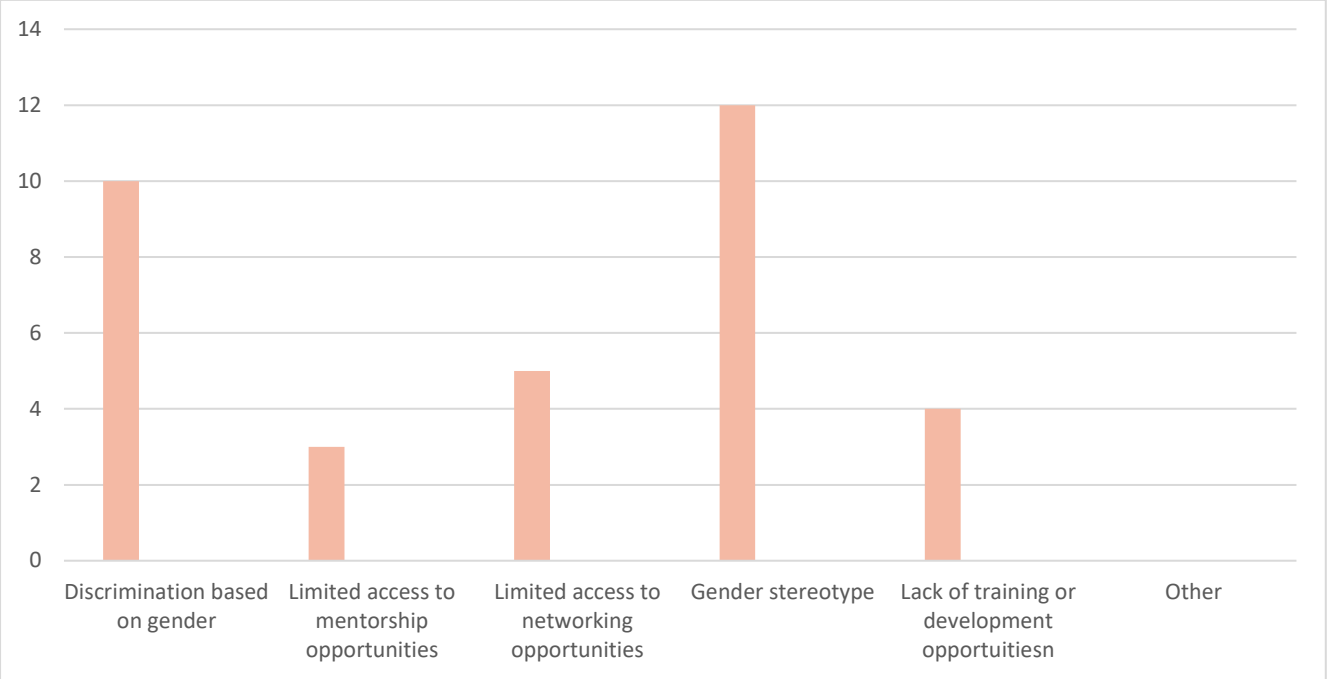
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	17	48.6	48.6	48.6
	Yes	18	51.4	51.4	100.0
	Total	35	100.0	100.0	



The table shows the responses of 35 participants to the question "Have you ever felt that you were passed over for a promotion or job opportunity because of your gender?" 18 participants (51.4%) answered "Yes," indicating that they have experienced gender-based discrimination in their careers. On the other hand, 17 participants (48.6%) answered "No," indicating that they have not experienced gender-based discrimination. These results suggest that almost half of the participants have faced challenges related to the glass ceiling in their workplaces.

Have you ever experienced any of the following barriers in your career development?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Discrimination based on gender	10	28.5	28.5	28.5
	Limited access to mentorship opportunities	3	8.6	8.6	37.1
	Limited access to networking opportunities	5	14.2	14.2	51.3
	Gender stereotype	12	34.2	34.2	85.5
	Lack of training or development opportunities	4	11.4	11.4	96.9
	Other	1	2.85	2.85	100
	Total	35	100	100	



This data represents the responses of individuals who were asked about the reasons they believed hindered their career advancement or growth. The options presented were discrimination based on gender, limited access to mentorship opportunities, limited access to networking opportunities, gender stereotype, lack of training or development opportunities, and other.

According to the data, the most commonly selected reason hindering career advancement was gender stereotype, with 34.2% of respondents choosing this option. Discrimination based on gender and limited access to networking opportunities were also selected by a significant proportion of respondents, at 28.5%

and 14.2% respectively. The remaining options - limited access to mentorship opportunities, lack of training or development opportunities, and other - were selected by fewer respondents.

Overall, the data suggests that there are multiple factors that can hinder career advancement, but gender stereotype, discrimination based on gender, and limited access to networking opportunities are perceived as the most significant barriers by the respondents.

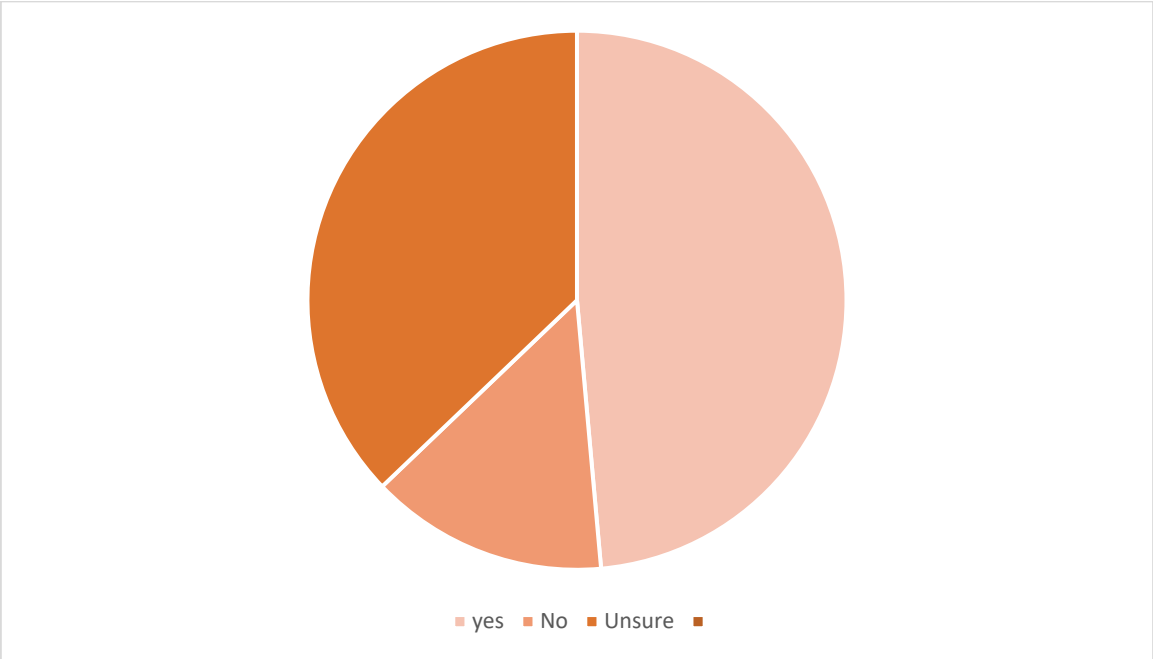
How do you think organizations can better support women's career development and overcome the glass ceiling?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Implementing mentorship and sponsorship programs to connect women with senior leaders and provide opportunities for career development	8	22.8	22.8	22.8
	Providing equal pay and benefits for men and women, regardless of their position or job responsibilities	10	28.5	28.5	51.3
	Developing flexible work arrangements that support work-life balance and accommodate women's caregiving responsibilities	5	14.2	14.2	65.5
	Encouraging diversity and inclusion in the workplace, including hiring and promoting women from diverse backgrounds	8	22.8	22.8	88.3
	Providing training and development programs that build leadership skills and address unconscious biases and stereotypes	4	11.4	11.4	100
	Total	35	100	100	

This data shows the responses of the participants to a question about potential solutions to address gender inequality in the workplace. 22.8% of participants suggested implementing mentorship and sponsorship programs to connect women with senior leaders and provide opportunities for career development. 28.5% of participants suggested providing equal pay and benefits for men and women, regardless of their position or job responsibilities.14.2% of participants suggested developing flexible work arrangements that support work-life balance and accommodate women's caregiving responsibilities.22.8% of participants suggested encouraging diversity and inclusion in the workplace, including hiring and promoting women from diverse backgrounds. 11.4% of participants suggested providing training and development programs that build leadership skills and address unconscious biases and stereotypes. Overall, the results suggest that participants believe that a variety of solutions are needed to address gender inequality in the workplace, including mentorship programs, equal pay, flexible work arrangements, diversity and inclusion efforts, and training and development programs.

Do you feel that your organization promotes gender equality in the workplace?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	5	14.3	14.3	14.3
	Yes	17	48.6	48.6	62.9
	Unsure	13	37.1	37.1	100
	Total	35	100.0	100.0	



This data shows the responses of 35 individuals to the question "Do you feel that your organization promotes gender equality in the workplace?".

Of the 35 respondents, 48.6% (17 individuals) answered "Yes", indicating that they feel their organization promotes gender equality in the workplace. On the other hand, 14.3% (5 individuals) answered "No", indicating that they do not feel their organization promotes gender equality in the workplace. The remaining 37.1% (13 individuals) were "Unsure" about their organization's promotion of gender equality.

Overall, the data suggests that a significant portion of the respondents feel their organization promotes gender equality in the workplace, but there are also some who do not feel this way or are unsure.

5. CONCLUSION

Based on the data presented, it can be concluded that gender inequality and discrimination still persist in the workplace. More than half of the respondents reported experiencing or feeling that they were passed over for a promotion or job opportunity because of their gender. Additionally, the most commonly cited

reasons for gender discrimination were gender stereotypes and limited access to mentorship and networking opportunities.

However, it is encouraging to note that the majority of respondents feel that their organizations promote gender equality in the workplace. Furthermore, the respondents identified several solutions to promote gender equality, including implementing mentorship and sponsorship programs, providing equal pay and benefits, developing flexible work arrangements, encouraging diversity and inclusion, and providing training and development programs.

In Albania, there are various initiatives aimed at promoting gender equality and empowering women in the workplace. For example, the Albanian government has implemented a National Action Plan for Gender Equality, which includes measures to promote women's employment and reduce gender-based discrimination. Additionally, various NGOs and private organizations are working to provide training, mentorship, and networking opportunities for women in the workforce.

Overall, the data suggests that while progress has been made towards gender equality, there is still work to be done to ensure that women are provided with equal opportunities for career advancement and are not subjected to gender discrimination in the workplace.

REFERENCES

[1] Heilman, M. E., & Parks-Stamm, E. J. (2007). Gender stereotypes in the workplace: Obstacles to women's career progress. In J. C. Chrisler, C. Golden, & P. D. Rozee (Eds.), Lectures on the psychology of women (5th ed., pp. 47-58). McGraw-Hill.

[2] Ragins, B. R., & Cotton, J. L. (1999). Mentor functions and outcomes: A comparison of men and women in formal and informal mentoring relationships. Journal of Applied Psychology, 84(4), 529–550.

[3] Zikmund, W. G., Babin, B. J., Carr, J. C., & Griffin, M. (2012). Business research methods (Qualtrics printed access card) (9th ed.). Cengage Learning.

[4] National Women's Law Center. (2020). The gender wage gap: 2020. https://nwlc.org/resources/the-gender-wage-gap-2020/

[5] Catalyst. (2021). Women in management: Quick take. https://www.catalyst.org/research/women-in-management/

[6] McKinsey & Company. (2020). Women in the workplace.

[7] Hymowitz, C., & Schellhardt, T. D. (1986). The glass ceiling: Why women can't seem to break the invisible barrier that blocks them from the top jobs. Wall Street Journal, 26, 1-16.

[8] Huse, M., & Solberg, A. G. (2006). Gender-related barriers and facilitators for career success: A longitudinal study. Gender in Management: An International Journal, 21(1), 20-33.

[9] Kramar, R., Bartram, T., & De Cieri, H. (2011). Women in management in Australia: Progress and prospects. Women in Management Review, 26(2), 91-109.

[10] Bendl, R., Fleischmann, A., & Schmidt, A. (2018). The glass ceiling and women's career advancement in Austria, Germany, and Switzerland. Gender in Management: An International Journal, 33(7/8), 452-467.

[11] Ellemers, N., Rink, F., & Derks, B. (2016). The glass ceiling in the Netherlands: Effects of job and organization context on perceived barriers and coping strategies. Sex Roles, 74(11-12), 527-541.

[12] Cela, E., & Kraja, F. (2021). The impact of gender stereotypes on women's career advancement in Albania. Journal of Management, 3(1), 25-35.

[13] Kraja, F., Isaraj, S., & Prendi, E. (2017). Career development challenges for women in Albania. International Journal of Gender and Entrepreneurship, 9(2), 181-197.

[14] Rroshi, A., Sulo, T., & Dervishi, I. (2018). Gender inequality in the Albanian labor market: The case of Tirana. European Scientific Journal, 14(2), 235-245.

[15] Seiti, J., Shtjefni, S., & Kapisyzi, E. (2017). The impact of the glass ceiling on women's careers in Albania. International Journal of Humanities, 5(2), 51-60.

[16] International Labor Organization (ILO). (2016). Women and Men in Albania 2016. Retrieved from https://www.ilo.org/wcmsp5/groups/public/---europe/---ro-geneva/---ilo-tirana/documents/publication/wcms_518150.pdf

[17] Friedrich Ebert Foundation (FEF). (2017). Women in Leadership Positions in Albania. Retrieved from https://library.fes.de/pdf-files/bueros/tirana/13359.pdf

[18] Albanian Center for Economic Research (ACER). (2018). Gender Pay Gap in Albania. Retrieved from http://www.acer.org.al/wp-content/uploads/2018/03/Gender-Pay-Gap-in-Albania.pdf

[19] European Bank for Reconstruction and Development (EBRD). (2021). Women in Business: Albania. Retrieved from https://www.ebrd.com/women-in-business/wib-countries/albania.html.

[20] Albanian Centre for Population and Development. (2018). Gender Equality in Albania. Retrieved from https://www.acpd.al/wp-content/uploads/2018/03/Gender-Equality-in-Albania-2018.pdf.

[21] Sopjani, L., & Ramadani, V. (2019). The Glass Ceiling Effect on Women's Career Advancement in Albania. Journal of Human Resources Management and Labor Studies, 7(1), 1-17.

Challenges in the Western Balkans: Infrastructure and Development in the Region

International Conference 2023

Tirana, 29-30 March 2023

Book of Proceedings / EPOKA University

Editors:

Prof. Dr. Hüseyin Bilgin

Mr. Bredli Plaku

Tirana

EPOKA University, 2023

ISBN 978-9928-135-40-7

1. Shkenca shoqërore 2. Zhvillim ekonomik 3. Konferenca 4. Gadishulli Ballkanik

CIP Katalogimi në botim BK Tiranë

Challenges in the Western Balkans
Challenges in the Western Balkans : Infrastructure and
Development in the Region : International Conference
2023 : Book of Proceedings : Tirana, 29-30 March 2023
/ Challenges in the Western Balkans ; edt. Hüseyin Bilgin,
Bredli Plaku. – Tiranë : Epoka University, 2023

147 f. ; 21 cm.

ISBN 978-9928-135-40-7

1.Shkenca shoqërore 2.Zhvillim ekonomik 3.Konferenca 4.Gadishulli Ballkanik

3(497) (062)

9 789928 135407